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Columbus first encountered the pineapple on his second voyage to America in 1493. This illustration is from Maria Sybilla Merian, *Dissertatio de Generatione et Metamorphosis Insectorum Surinamensium*, and is featured in the exhibit *Encountering the New World, 1493-1800*. Courtesy John Carter Brown Library.

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French firing line, Segesser II Hide
Painting. Courtesy Palace of the
Governors, Museum of New Mexico.

Acquisitions

THE NATURAL HISTORY Museum has recently received a large gift of ethnological, archaeological, and historical artifacts from Ed N. Harrison, longtime president of the museum's Board of Governors.

The ethnological specimens given to the Anthropology Section consist of basketry, pottery, kachinas, jewelry, clothing, tools, Navajo horse bits, and bridles. The archaeological donation is composed of ceramics, stone tools, pipes, and figurines.

Southwestern pottery is particularly well represented in this acquisition and improves the museum's collections of late nineteenth- and early twentieth-century Pueblo pieces, as well as providing more modern examples. Of interest are an early 13-inch high Santa Clara Black jar, circa 1890-1910, and two effigy vessels from Cochiti, collected during the 1880s.

Mr. Harrison's donation of an early collection of archaeological ceramics is an important one. Probably the most significant aspect of

this earlier pottery is a systematic collection of Anasazi seed jars, bowls, mugs, pitchers, and stone tools gathered by Mr. Harrison's father from southeastern Utah and southwestern Colorado. Each piece is numbered and corresponds to an original typed list from the early 1900s. Collections such as these played an important part in the development of Southwestern archaeology. This is the first such one received at the museum, because at the time these avocational collections were made, most of them were shipped to established museums on the East Coast or to European institutions.

Several significant kachinas were donated; two are Zuni and represent *Koyemsi*, a mudhead dancer, and *Sipkne*, a guard. Since Zuni examples are not well represented in our collections, these are a welcome addition.

A sizeable basket donation includes two excellent Pomo feathered gift baskets decorated with clam shell beads and abalone shell pendants and a large collection of

contemporary miniatures, which are only a half-inch to about three inches in size; several are covered with feathers and others with beads smaller than the head of a pin. Certain miniature baskets are woven from horsehair; weavers used the various colors of hair from the tail or mane of a horse to form the contrasting design motifs. The Pomo gift baskets will be used in Native American Hall and the miniatures were exhibited during Open House last March.

Complimenting the Southwestern archaeological materials are some exceptionally fine artifacts collected at the turn of the century from the Southeastern area of the United States. These are beautiful specimens of Woodland and Mississippian animal effigy stone pipes, discoidals, bannerstones and gorgets, a seated human figurine, and ceramic human effigy vessels. Several of the effigy pipes from Kentucky and Tennessee will be featured in a History Division exhibit.

A large chipped stone tool collection consisting of spear points,

A striking item from the Plains is a traditional Crow buckskin shirt decorated with fine beadwork, fur, and horsehair fringe. It will be exhibited in the Native American Hall.



Don Meyer

knives, scrapers, and effigy and eccentric pieces fills a void in the archaeology holdings. Several types of classic Paleo Indian points such as Clovis, Folsom, and Yuma are well represented.

Mr. Harrison also donated several important items to the Seaver Center for Western History Research, including three watercolors by the well-known photographer William Henry Jackson. The paintings, apparently done in 1941, a year before the artist's death at the age of 99, depict the Grand Tetons, mining in the West, and a scene from a village in New Mexico or Arizona. Although Jackson was an accomplished artist, his reputation rests primarily on his work as a Western landscape photographer. He served with the U.S. Geological Survey of the Territories and made countless photographic expeditions into the mountains and deserts of the West. Today Jackson's original photographs are prized collector's items.

The museum also received several mining lamps and two dolls from Mr. Harrison, a gift that exemplifies the broad range of objects collected by the History Division to help tell America's and California's history. Mining and gold are subjects frequently associated with California; Mr. Harrison gave three miner's candlesticks — known as "sticking tommies" — and an unusual tin oil-wick lamp that all date from the nineteenth century. Because the Natural History Museum loans mining items to institutions throughout the U.S. for research and exhibit purposes, these artifacts are particularly welcome additions.

Even more important than the lighting devices, however, are two Skookum Indian portrayal-type dolls. First produced around 1913 by Mary McAboy of Missoula, Montana, using dried apples for heads, these dolls originally were modeled after Native Americans who lived on nearby reservations. The dolls became popular, and Ms. McAboy began having them manufactured with composition faces, a



John De Leon

design on which she obtained a patent. During World War I it was difficult to import ceramic doll heads from Europe, and American manufacturers began to develop improved wood pulp and glue, rag, and papier-mache combinations to create doll heads. Skookum dolls are typical early examples of this new technology. They were manufactured through the 1950s, and are interesting not only to those studying the portrayal of Native Americans, but to students of American history. "Skookum" is a Siwash Indian word meaning, roughly, "bully good." The Siwash tribe lived in the northwestern U.S.

CHRIS COLEMAN
Curatorial Assistant, Anthropology
Section

BETH WERLING
Collections Manager, General American
Section

ERROL STEVENS
Curator, Section Head, Seaver Center
for Western History Research

The objects that museums acquire and preserve are in effect a permanent record of human endeavors and the natural world: at the heart of all of the Natural History Museum's activities are its collections. In Acquisitions, TERRA showcases a recent addition to the museum's holdings of more than 35 million specimens and artifacts.

The Anthropology Section has an active commitment to collect contemporary Native American pieces; therefore the fine collection of contemporary miniature pottery that was recently donated to the museum by Ed Harrison is an important acquisition. The miniature ceramic jars and seed bowls vary in size from a half-inch to three inches. The black-on-white or polychrome geometric, human, and animal forms are reminiscent of Prehistoric Anasazi motifs, such as the pattern on the large jar here. These miniatures are about 1-1/2 inches in diameter, while the large jar, dating from 1200 A.D., is about 12 inches high.

The Current Status of Butterfly Royalty

MONARCHS AND VICEROYS REVISITED

by Lincoln P. Brower

INSPIRED BY THE GENERAL FERVOR of natural history in mid-19th-century England and by an account of fabulous butterfly collecting in Amazonia by the American lepidopterist William Henry Edwards, two young Englishmen set sail in the spring of 1848 for Brazil to collect specimens and to gather facts toward solving the problem of the origin of species. After exploring the main stem of the Amazon for a year, Alfred Russel Wallace penetrated northward up the Rio Negro, while Henry Walter Bates explored the great river's southwestern tributaries. Four and a half years later, Wallace started back to England with a treasure of live and preserved specimens that would have paid for his trip, but alas, his ship caught fire and sank. Undaunted and feeling lucky to have survived, Wallace soon left England again for the Malay Peninsula. (Within five years, Wallace would have independently discovered the theory of natural selection.) Meanwhile, Bates had persisted in collecting in Amazonia for seven more years. On his return to England in July of 1859, he landed in the flurry of intellectual activity that was associated with Darwin's completion of *The Origin of Species*, finally published in November of that year. After sorting and classifying his large collection of insects, Bates in 1862 published a theory of mimicry that Darwin instantly recognized as important. He wrote Bates, congratulating him for discovering the clearest example of how natural selection operates in nature.

Bates and Wallace knew from their early days of collecting together in England that butterflies are easily classified on the basis of their morphological characters. Different families of butterflies, for instance, differ in wing shape and body size, in the arrangement of veins that form the superstructure of the wings, in the sizes and degrees of development of the various legs, and in many other very esoteric characters that delight taxonomists. Further delving indicated that related butterflies produce similar caterpillars, while those in distinct taxonomic groups are very different. In Amazonia, Bates was puzzled by the fact that several butterfly species had adults that looked almost exactly alike in color pattern and wing shape, yet on closer examination of their morphologies, proved to be in widely separate families. Since their shared appearance could not be explained by common ancestry, Bates theorized that the adult butterflies of one of the species must be mimicking the other. How could the evolution of this mimicry between totally unrelated butterflies be explained?

The facts and ideas that led Bates to formulate his theory of mimicry were that (1) species belonging to several distinct families of Amazonian butterflies are extremely wary of predators and have

various inconspicuous or confusing color patterns and behaviors by which they avoid being seen or caught; (2) in contrast, numerous other species belonging to other families are brightly colored and literally flaunt themselves in front of birds, lizards, and other potential predators; (3) since Bates never observed vertebrates attacking these gaily colored species, he deduced that they must be unpalatable, whereas the others must be palatable; (4) a few species belonging to the palatable groups had color patterns and behaviors that were anomalous for their own group but similar to those of butterflies in the unpalatable groups. He termed these palatable look-alikes the *mimics*, and the unpalatable species that they resembled the *models*. He theorized that individual predators would learn to avoid models after experiencing their unpalatability. Then, because the mimics look so much like their models, the predators would avoid both. Thus the mimics would gain an advantage by deceiving the predators. Obviously such mimicry would only work if the palatable mimics were not too common. Bates emphasized that the mimicking species were in fact very rare.

Bates postulated that the mimic originally resembled the other non-mimic species in its own taxonomic group, but that at some point in the remote past a "heritable variation" (now called a mutation) occurred, resulting in a change in the color pattern of an individual butterfly which by chance looked slightly like the unpalatable model. Predators, he reasoned, would more likely be confused by and therefore avoid these incipient mimics while still attacking their relatives who retained the non-mimetic ancestral pattern. This differential killing of the non-mimics by the predators would result in the incipient mimics leaving more offspring to the next generation; this predator-driven differential mortality is the essence of natural selection. Eventually a second mutation would arise in an individual that by chance made the resemblance a bit better, and by the same process of selective predation, the slightly better mimic form would replace the earlier one. New mutations and relentless natural selection favoring each of the slightly better mimic forms over thousands of generations would gradually lead to the evolution of the startling mimetic resemblances Bates had discovered in Amazonia.

Ironically, mimicry involved so many species in the South American tropics that Bates himself was deceived into lumping two major groups of butterflies as one. It was not until 1879 that the German naturalist Fritz Müller solved the confusion by deducing that there are two very different kinds of mimicry, which were then given separate names. As we have seen, *Batesian mimicry* involves a

Monarchs clustering at an overwintering site near Angangueo, Mexico, Michoacán.



Müllerian Mimicry in Neotropical Butterflies from Trinidad

Heliconiinae



Heliconius e. erato



Heliconius m. melpomene



Heliconius n. numata



Eueides i. isabella



Heliconius d. doris



Heliconius s. sara



Dryas iulia alcionea



Agraulis vanillae

1) Four mimetic pairs of unpalatable *Heliconius* species from the American Tropics that have converged in color pattern and are Müllerian mimics of each other. The butterflies were all collected by the author on the island of Trinidad off the coast of Venezuela.

palatable species mimicking an unpalatable model. In *Müllerian mimicry*, two or more unpalatable species mimic each other. Unlike Batesian mimicry in which mimic and model always belong to very different taxonomic groups, Müllerian mimics can share their mimicry either with related or with completely unrelated groups of unpalatable butterflies. Two of the most famous groups of Müllerian mimics involve the South American Heliconiine (Figure 1) and Ithomiine (Figure 2) butterflies. Within each of these groups, many pairs of species resemble each other. However, some species of unpalatable Heliconiines share their color with unpalatable species in the Ithomiine group. This is precisely what confused Bates; he failed to realize that two unpalatable groups had converged on a common color pattern through what would come to be known as Müllerian selection.

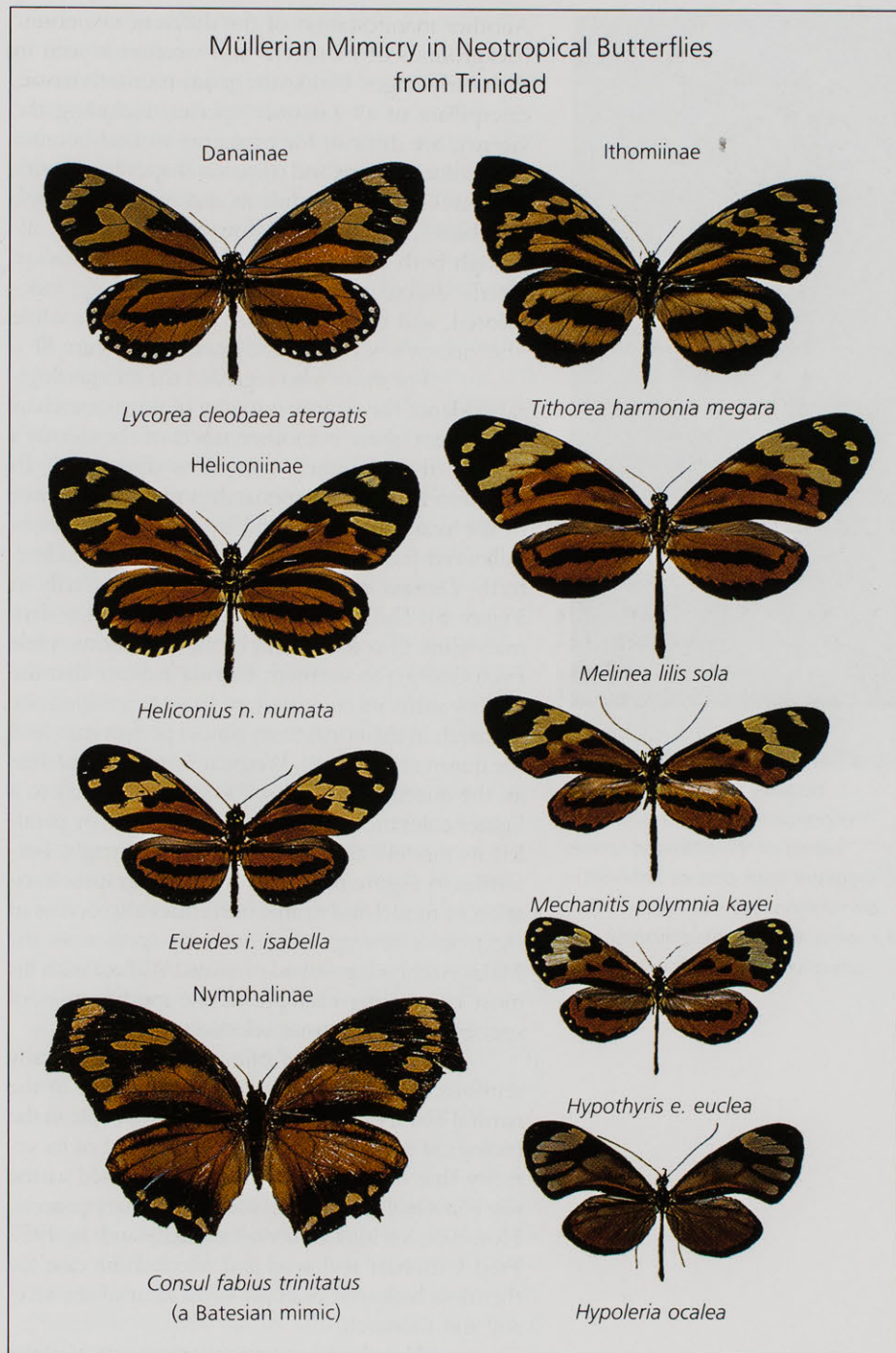
The enormous selective advantage gained by Müllerian mimicry is elegantly simple to understand: assume that each of two equally abundant unpalatable species had a distinct color pattern (say black and red versus blue and yellow). If each predator had to kill five red and black individuals of species A and five blue and yellow individuals of species B before learning that each were unpalatable, then a total of 10 butterflies would be killed. However, if the two species mimicked each other, there would be only one color pattern to learn and the total number of butterflies sacrificed to the predators' learning the warning color pattern would be only five, a mortality reduction of 50%! The evolutionary outcome of Müllerian mimicry through eons of time has been the multiplication of literally scores of unpalatable species — both within and between taxonomic groups — that have come to look alike.

Bates and Müller had both assumed that models are unpalatable to predators. Through time, it emerged that their insights became supported by a remarkable biological coincidence: the caterpillars of each of the taxonomic groups of purportedly unpalatable butterflies feed on distinct taxonomic groups of plants; and each of these plant groups produces a different class of extremely poisonous and bitter chemicals. Thus it was discovered that the caterpillars of the South American Heliconiine butterflies feed mainly on plants of the Passifloraceae; *Passiflora* leaves contain cyanogenic glycosides that release hydrogen cyanide when digested. Danaine butterflies, including the monarch, lay their eggs on milkweed plants (*Asclepias*) that contain cardiac glycosides, potent natural chemicals that poison vertebrate hearts. Ithomiine butterflies (Figure 2) and the unpalatable Troidine swallowtails (including *Battus philenor*, the bottom right butterfly in Figure 7) lay their eggs on plant

groups that contain neurotoxic alkaloids. In contrast to these various groups of model butterflies, the palatable mimics oviposit on a wide array of plant families that generally lack noxious substances. Such a strong *correlation* inexorably led to the theory that unpalatability in the model butterfly species was *caused* by the ability of the caterpillars to sequester the poisonous substances from their foodplants. The idea of chemical sequestration, without experimental support, became widely accepted in the early 20th century. We will return to it shortly.

Within a few years after the discovery of Batesian mimicry, two American entomologists, Benjamin Walsh and Charles Riley, described in 1869 what has become the most famous example of all, that of the North American viceroy butterfly, *Limenitis archippus*, that mimics the monarch butterfly, *Danaus plexippus* (Figure 6, left). The relationship from the beginning was assumed to be Batesian, because the monarch belongs to the tropical subfamily Danainae whose species feed on poisonous milkweeds and related toxic plants. Monarchs epitomize the concept of a Batesian model: their caterpillars have alternating bands of yellow, black, and white as well as wobbly tentacles protruding from the bodies, and they are extremely conspicuous on their foodplants (Figure 3). The adults similarly flaunt their warning coloration: the wings are orange with black lines, while prominent white spots dot both the black edges of the wings and the dark body (Figure 4). Unlike viceroy adults and their relatives, which scatter and individually hide in the foliage to avoid predators, monarch adults increase their conspicuousness to predators through extremely gregarious behavior that reaches a biological apogee at their overwintering aggregations in California and Mexico (Figure 5).

Although viceroy adult coloration closely mimics that of the monarch (Figure 6), Austin Platt of the University of Maryland has proven that its ancestral color pattern looked nothing like the monarch, but rather was similar to its close North American relative, *Limenitis arthemis*, the butterfly shown at the bottom center of Figure 7. The white bands of the highly palatable *L. arthemis* are typical of scores of other known *Limenitine* species. The color banding functions to protect these butterflies from bird predators as they fly through sun-dappled forest glades where the high-contrast light falling on white and dark wings makes the butterflies virtually impossible to track visually. An ancestor of this so-called "white — banded purple" butterfly also gave rise to another Batesian mimic, *Limenitis astyanax*, the top right butterfly in Figure 7, which copies the extremely unpalatable *Battus philenor* (the bottom right butterfly in Figure 7).



2) Four pairs of so-called "tiger-patterned" butterflies collected in Trinidad show the complexities of mimicry in the tropics. The *Heliconius* and *Lycorea* butterflies have converged as Müllerian mimics with the Ithomiines because all of them are unpalatable. *Protogonius*, at the bottom left, is a rare and palatable Batesian mimic of the rest of the butterflies in the complex.



Lincoln P. Brower

3) A full-grown larva of the monarch butterfly feeding on *Asclepias eriocarpa* in California. Monarchs reared on this milkweed species sequester heart poisons sufficient in amount to make more than 16 Blue Jays vomit. Because it is poisonous, the caterpillar is able to flaunt a bright warning coloration.

Another manifestation of the different taxonomic backgrounds of monarchs and viceroys is seen in their early stages. Unlike the gaudy monarch larvae, caterpillars of all *Limenitis* species, including the viceroy, are difficult for predators to find because their color patterns and tortuous shapes blend with the leaves of their foodplants and make them look like bird droppings (Figure 8a). Likewise, although both are camouflaged, their chrysalids are utterly different: the monarch's is smooth, jade-colored, and bespeckled with golden spots, while the viceroy's is brown and bark-like (Figure 8b).

For those who regarded the morphological evidence for viceroy mimicry of the monarch as insufficient, there is another aspect of the viceroy's biology that the early naturalists discovered. In southern Florida, the monarch is rare during most of the year, but is replaced by another species of milkweed-feeding Danaid, the Florida queen butterfly, *Danaus gilippus* (the top center butterfly in Figure 6). Unlike the monarch, the queen is dark mahogany in color. Remarkably, collections made from Georgia to southern Florida indicate that the viceroy shifts its color pattern from mimicking the monarch in the north to an almost perfect match of the queen in the south. Westward from central Texas, the queen butterfly itself shifts from a dark to a lighter coloration, and here again the viceroy parallels its model's changing color pattern (right butterflies in Figure 6). This parallel geographic variation of model and mimic butterflies also occurs in the tropics among other butterfly species; in the Malay Archipelago it had provided Wallace with his most compelling example of the modification of species through natural selection.

The theory of mimicry was dramatically reinforced by the accumulating knowledge of the natural history of butterflies and most people in the biological community were so convinced of its veracity that examples of mimicry were used as the *sine qua non* illustration of the evolutionary process. However, various doubters existed, and in 1957 Fred Urquhart reviewed and rejected the case for the most hallowed example of all, that of the viceroy and monarch.

Urquhart was particularly skeptical of the evidence that birds are selective predators; his criticisms underscored the fact that nearly a century had passed without direct tests of the assumptions underlying mimicry. For example, (1) Are the so-called Batesian models really unpalatable to birds? (2) Can naive individual birds learn to avoid the models? (3) If so, will they then confuse the mimic with the model and reject the mimic on sight? (4) What about the first steps in the evolution of a mimic, i.e. do birds really confuse incipient mimics with their models? And, (5) can the advantage of

mimicry actually be measured in the natural environment? Solid answers to these questions began emerging when Jane Van Zandt Brower and Lincoln P. Brower and their students initiated a series of experimental studies in the 1950s.

After months of planning an appropriate experimental design at Yale University where the Browsers were working on their Ph.D. degrees, Jane Brower set out to test mimicry of the monarch by the viceroy using the fine experimental facilities of the Archbold Biological Station in Florida. The predator would be Scrub Jays, then common on the station grounds. Eight jays were caught, individually caged so that they could not see each other, and divided into two groups, one designated the experimental group and the other the control group. The first step in the experiment was to assure that the birds would eat butterflies. All eight attacked, tore off the wings, and avidly ate swallowtail butterflies that were given to them. Once the birds freely accepted the palatable swallowtails, the four experimental birds were given monarch butterflies, and finally were offered viceroys.

The experimental birds attacked monarchs, pecked them apart, and tasted them, but resolutely refused to eat them. Thus the experiment indicated that the monarch, long purported to be a model butterfly, indeed is unpalatable to Scrub Jays. Moreover, while still accepting the yellow and black swallowtails, three of the four birds rejected most subsequent monarchs on sight. This behavior answered the second question: birds indeed can learn to associate the bright orange and black color pattern with the monarch's unpalatability. In the parlance of learning theory, the birds became visually conditioned to avoid the unpleasant-tasting monarchs. Once they were conditioned, the critical test of mimicry was possible: instead of offering the bird another monarch, a viceroy was slipped into its cage. Three of four birds rejected their first viceroy on sight, and in the entire experiment, these three birds visually rejected 86% of 43 viceroys they were offered. They clearly failed visually to discriminate the similar color patterns of the viceroy and monarch. This was strong evidence that the viceroy was protected by mimicking the monarch. However, to clinch the argument that their rejection of viceroys was due to visual mimicry, it was necessary to show that the control birds, which had not been given monarchs, would attack viceroys. Three of the four controls attacked and ate 79% of the total of 75 viceroys that they were offered. Thus birds that had experienced monarchs avoided viceroys, while those that had not experienced monarchs accepted them.

Jane Brower's experiment established that the viceroy is an effective mimic of the mon-

arch, but it did not answer the question of how mimicry could have evolved from the viceroy's white-banded black ancestor shown at the bottom of Figure 7. More generally, how different can a mimic be from its potential model and still be avoided by a bird that has learned to reject the model? Darwin realized that this question was central to his thesis that evolution occurs through the accumulation of numerous small changes — *micromutations* — over an enormous extent of time. Deciphering how incipient mimicry derives an advantage thus was central to understanding how evolution occurs.

Resolving this problem has required extensive research on two fronts: more experimental studies of how birds behave toward model and mimic butterflies, and careful investigation of the kinds of heritable mutations that control the color pattern elements in mimetic species. We will return to the birds after considering the genetic evolution of mimetic patterns in butterflies.

The American geneticist Richard Goldschmidt (1878-1958) rejected the Darwinian micromutation view and argued that the initial mutation in an individual butterfly within a species that was destined to become mimetic could not have had a small effect. He reasoned that a tiny change in pattern or color would not confuse the birds. Therefore, the incipient mutation would have to cause an entire group of changes in the butterfly color pattern. Goldschmidt termed this postulated genetic change a *macromutation*. His hypothesis was important because it promulgated the idea of macroevolution, which Steven Jay Gould and Niles Eldridge rechampioned in their now-famous 1977 paper on the subject of punctuated, rapid evolutionary changes in time.

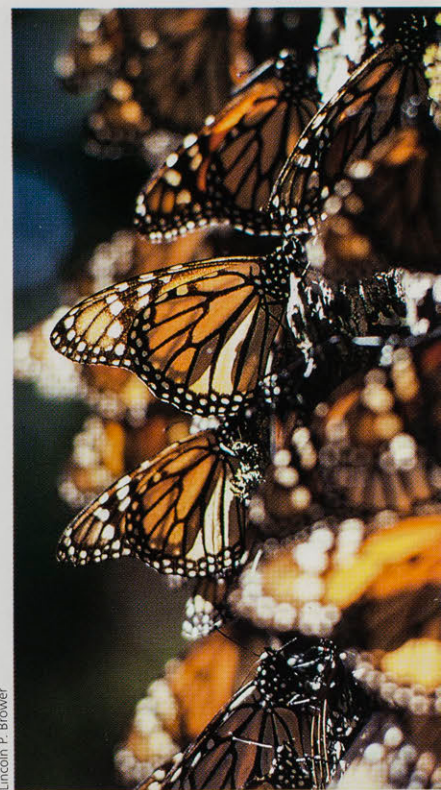
As might be expected, the English butterfly geneticists vehemently confronted Goldschmidt, holding to the Darwinian position that evolutionary change is fueled by micromutations, those mutations that cause only small changes in an individual's appearance. Goldschmidt cited as evidence for his macromutation hypothesis the fabulous African mimetic butterfly, *Papilio dardanus*. *Dardanus* has several different female forms that each mimic a different species of model butterfly, each of which differs extraordinarily in its color pattern. Goldschmidt knew that each of these mimetic forms in *P. dardanus* segregated independently just as did Mendel's red and white pea flowers. Thus eggs from a female *dardanus* of form A could produce forms A, B, C, and D, each mimicking a different species of model. He reasoned that each of these forms had risen initially as a separate macromutation. However, elegant genetic breeding experiments by E.B. Ford, P. M. Sheppard, and

C.A. Clarke decisively proved that each different mimetic form is in fact controlled by a complex of micromutations. The reason the forms appear to be macromutational is, because several genetic loci, each controlling a part of the color pattern, are so closely linked that each form is kept intact as a segregating genetic unit. Ford, et al, called this a "supergene." Thus what superficially appeared as Goldschmidtian macromutations really were not; Ford and his colleagues thus correctly reinterpreted the genetics of *Papilio dardanus*.

Recent genetic studies carried out by Austin Platt provide strong evidence that the evolution of mimicry of the monarch by the viceroy has likewise been through the accumulation of many small mutational changes. By hybridizing and backcrossing the viceroy to its presumed ancestral species, the white-banded purple butterfly (*Limenitis arthemis*), Platt has been able to reconstruct the series of forms that evolved from each other over thousands of years. A selection of Platt's hybrids show this beautifully (Figure 7). The same figure shows how the white-banded *artemis* butterfly also gave rise to a Batesian mimic, *Limenitis astyanax*, of the pipevine swallowtail butterfly, *Battus philenor*.

While genetic evidence clearly falls on the side of the micromutationists, Goldschmidt's questioning of how the initial micromutational steps could be selectively favored by birds remained a difficult problem. Would a bird that had learned to refuse a monarch also refuse a mutant viceroy that had departed little from its ancestor, retaining much of the white band and with the addition of only a small amount of orange? (See Figure 7). In other words, is the behavior of bird predators really able to provide a selective basis for the evolution of mimicry by gradual, micromutational steps?

In the 1960s the Browsers and their student, John Alcock, now Professor of Animal Behavior at Arizona State University, experimentally tested this hypothesis in Trinidad, an island off the coast of Venezuela that has a rich neotropical biota. Among the native butterflies are several of Bates' *Heliconius* models, one of which, *Heliconius erato*, is jet black with a striking scarlet patch on each forewing. Birds tasted and rapidly learned to reject *erato*, again proving Bates right. Virtually perfect Müllerian mimics of *H. erato* occur, such as *Heliconius melpomene* (Figure 1), but in this experiment we decided to test one that was imperfect: *Biblis hyperia*. This butterfly is about the same size and color as *H. erato*, but differs in having the red coloration as a band on the edge of the hind wing (Figure 9). As long as alternative prey were available, our caged birds that had learned to avoid *H. erato* were unwilling to attack *Biblis*. We then used



Lincoln P. Brower

4) Adult monarchs likewise flaunt warning coloration and may or may not be poisonous to birds, depending on which species of milkweed they ate as larvae and on their age.



Lincoln P. Brower

5) Because of their unpalatability, monarchs are able to form social aggregations which are key to their survival during the winter. This photograph was taken at the Sierra Chinqua overwintering site of the monarch high in the mountains of central Mexico.

magic marker to black out the red color on *Biblis*, and the birds continued to reject it most of the time. Thus having only a single major color in common — black — was sufficient to provide *Biblis* with at least some mimetic advantage.

This experiment determined that detailed resemblance is not necessary because the birds become conditioned to avoid a generalized color pattern of unpalatable prey. Such generalization is only likely to occur as long as distinctively colored tasty prey are present. On the other hand, when alternative tasty prey become rare relative to the model and mimic, then the birds, hungrier, will be forced to make a finer discrimination and will tend to eat the poorer mimics but reject the better ones. This fine discrimination is what provides the selective basis for continually improving the mimicry through many generations until mimic and model are virtually indistinguishable. Generalization favoring incipient mimicry, and discrimination favoring its tendency to perfection are opposite sides of

the behavioral coin that is the key to understanding how mimicry evolves under the selective milieu exerted by predators.

These and other experiments with predators, natural models, and mimics, as well as elaborate genetic studies, have supported the theory of mimicry and elucidated how it can evolve. But does mimicry really work in nature? While immersed in the rich biota of Trinidad, Lincoln Brower pondered on how to make a decisive test. The island of Trinidad is a natural laboratory with a subset of the Amazonian fauna including many model and mimic butterflies and insectivorous birds. Direct observation of birds attacking models and avoiding mimics was unfeasible because of the impossibility of making frequent enough observations. Brower remembered his early experience in New Jersey with a large silkworm known as *Hyalophora promethea*. Unlike other silkworms such as the familiar *luna* and *cecropia* moths of the eastern U.S., which fly only at night, male *promethea* moths fly during



6) The viceroy butterfly, *Limenitis archippus* mimics three different models in different parts of its geographic range. In northeastern North America, it mimics the monarch butterfly (*Danaus plexippus*) and is called *Limenitis archippus archippus*. In central and southern Florida, where the monarch is rare during most of the year, the viceroy is called *Limenitis archippus floridensis* because it shifts its color pattern and mimics the more common Florida queen butterfly, *Danaus gilippus berenice*. To the west in southern Texas, the queen butterfly lightens in color and is called *Danaus gilippus strigosa*. Here the viceroy shifts its color pattern again, and is called *Limenitis archippus obsoleta*. Such parallel geographic variation of mimic and model provided key evidence for natural selection in the history of evolutionary biology. Photograph by Austin Platt and Lincoln Brower.

the daytime and when released into the air are mercilessly attacked by birds. Like other silkmoths, the females secrete a sexual pheromone that attracts their males from up to several km away. Because *promethea* are active during the afternoon, they intermingle with butterflies, and as they fly erratically about in search of their females, they expose themselves to hungry birds. So here was an experimental opportunity: collect *promethea* moth cocoons in North America, hatch them out in Trinidad, paint the males to resemble a common local model butterfly, release them along with painted non-mimetic control butterflies and lure them back through the gauntlet of birds into traps containing their pheromone-releasing females.

If Batesian mimicry were working, we should expect the birds to avoid the painted mimics and eat the controls. Initially we did recapture more mimics than controls in the traps, but apparently the hungry tropical birds caught on so fast to our deception that the initial excess of mimics rapidly diminished. Though we persisted for three summers and released several thousand painted male *promethea*, our final results were frustratingly indecisive. However, great success ensued about a decade later when M.R. Jeffords, James Sternburg, and Gilbert Waldbauer repeated the experiment in Illinois: here *promethea* painted to resemble the monarch butterfly as well as the toxic swallowtail *Battus philenor* (Figure 7, bottom right) were more frequently recaptured than those painted to resemble palatable tiger swallowtail butterflies, *Papilio*

glaucus. At last, evidence obtained in the wild supported the Batesian mimicry hypothesis of unpalatable models and palatable mimics.

Proof that monarchs obtain their unpalatable character by sequestering plant poisons from milkweeds came during 1967 simultaneously from chemical studies by Nobel laureate Tadeus Reichstein in Switzerland and from experiments by Lincoln Brower and his students at Amherst College. Using monarchs that Brower had reared on the tropical American milkweed, *Asclepias curassavica* from Trinidad, Reichstein chemically proved that the bodies of monarchs do indeed contain the cardiac glycosides that are synthesized by the milkweed. Brower, meanwhile, had assumed from the historical literature that all milkweeds must contain these heart poisons. He therefore decided that the only way to test the sequestration hypothesis was to force monarchs to eat cabbage leaves which lack the cardiac glycosides and compare the birds' reactions to monarchs reared on cabbage *versus* monarchs reared on milkweed. By putting hundreds of young monarch caterpillars on cabbage seedlings painted with extract of milkweed leaves, Brower and his students succeeded in selecting a biological strain that could survive on cabbage plants. The resulting larvae and adult monarchs were then offered to Blue Jays. Though initially reluctant, the jays eventually attacked and ate them with impunity. We then offered them monarchs that we had reared on the poisonous *Asclepias curassavica*. Because they looked exactly like the

7). Through elegant hybridization experiments, Professor Austin Platt has reconstructed the evolutionary development of mimicry from the white-banded purple butterfly, *Limenitis arthemis*, shown at the bottom of the photograph. On the left are four steps leading to *Limenitis archippus*, the familiar viceroy that mimics the poisonous monarch butterfly, bottom left. On the right are four steps leading to *Limenitis arthemis astyanax*, the red-spotted purple butterfly that mimics the poisonous swallowtail butterfly, *Battus philenor*, bottom right. The viceroy, long thought to be a Batesian mimic, is now known to be an unpalatable Müllerian mimic of the monarch. The red-spotted purple, on the other hand, has retained its palatability and is a classical Batesian mimic of *B. philenor*.

Photograph by Austin Platt and Lincoln P. Brower.



BELOW LEFT

8a) Camouflage and resemblance to bird droppings typifies the color pattern of the larvae of *Limenitis* butterflies, top, and is indirect evidence that the caterpillar is palatable to birds and other predators.

The monarch larva (bottom), on the other hand, typifies the warning coloration of poisonous insects with its gaudy yellow, black, and white banding. This correlation was evidence that led early naturalists to assume that the viceroy adult is a palatable Batesian mimic of the monarch. While monarch larvae that feed on toxic milkweeds are poisonous, the palatability status of *Limenitis* caterpillars remain untested.

Photograph by Lincoln Brower and Linda S. Fink.

BELOW RIGHT

8b) The utterly different shape and color pattern of the chrysalids of the monarch (left) and viceroy (right) tell us that the two butterflies, in spite of the near identical resemblance of their adults, really belong to very different taxonomic groups, the Subfamilies Danainae and Nymphalinae, respectively. Photograph by Linda S. Fink.



cabbage-reared monarchs, the birds quickly swallowed them. Within minutes the birds sickened, hunched down on their perches, and one after another began vomiting, retching, and vehemently wiping their bills (Figures 11-14). The next day it did not matter whether the monarchs had been reared on cabbage or milkweed: the birds resolutely refused to peck any of them. One bird even retched at the sight of a monarch. At last, the 19th-century hypothesis that model butterflies can obtain their unpalatable character from the poisonous plants their larvae eat was experimentally supported.

In later experiments we raised monarchs on several different species of milkweed and compared the degree to which they sicken the jays. Much to our surprise, monarchs reared on some milkweed species were completely palatable, while those reared, for example, on the California *Asclepias eriocarpa* (Figure 3) contained enough cardiac glycoside to make more than 16 jays vomit. Because there are 108 species of milkweed in North America, we predicted that monarchs from the wild would vary in palatability depending on which species of milkweed their larvae ate. Our experiments have confirmed this: wild monarchs exhibit a palatability spectrum from completely palatable to dangerously unacceptable. As a result, birds are subjected to a game of "emesis roulette" if they attack and eat monarchs in the wild.

Luck plays important roles in scientific discovery, and did so in Jane Brower's initial mimicry studies with Scrub Jays in Florida. Lincoln Brower's task was to provide the butterflies, and he collected the models from a site that supported a mixed population of monarch and queen butterflies that were breeding on two species of milkweed, *Asclepias humistrata* and *A. tuberosa*. *A. humistrata* epitomizes milkweeds by producing copious latex when its leaves are damaged (Figure 10), whereas *A. tuberosa* does not bleed the milky fluid. Since the literature frequently referred to the bitter latex of milkweeds as the source of the monarch's purported unpalatability, Brower tasted it; not only was it bitter, but it caused copious salivation and nausea. Eleven years later we determined that a single monarch reared on *A. humistrata* contains enough cardiac glycoside to make 14 Blue Jays vomit. In contrast, monarchs reared on *A. tuberosa* are completely palatable to the jays because this milkweed has virtually no cardiac glycosides in its leaves. Thus, had we collected our monarchs and queens from a habitat where only *A. tuberosa* was growing, Jane Brower's experiments would have ended up supporting Urquhart's doubts about the monarch's unpalatability. This serendipity played a large part in determining the course of the next 30 years of



Heliconius erato



Biblis hyperia
(red margins normal)



Biblis hyperia
(red margins darkened)



Anartia amalthea



Anartia amalthea
(upside down)



Anartia jatrophae

9) Neotropical tanagers were offered this series of butterflies to see if incipient resemblances of a palatable mimic to a model can gain a selective predatory advantage. The birds were offered the unpalatable *Heliconius erato*, which they learned to reject. Most of the birds then also rejected palatable *Biblis hyperia* butterflies that share the colors with the model *H. erato* but differ in the pattern, having the red on their hindwings. They also rejected *Biblis* butterflies that were made uniformly black by painting out the red wing margins, and they even rejected some of the red-banded *Anartia amalthea* which otherwise is very different in color pattern from the

model *H. erato*. When *A. amalthea* was turned upside down obscuring its red bands, the birds treated it like *Anartia jatrophae* by consistently attacking and eating it. The key to whether birds will generalize is the availability of alternative food. If it is present, they do generalize, providing a substantial advantage to incipient mimics. On the other hand, if alternative palatable prey are rare or absent, then the birds are forced to discriminate carefully in order to obtain sufficient food. The two sides of the behavioral coin provide an advantage for incipient as well as detailed resemblances in the evolution of mimicry.

10) Milkweed plants derive their name *Asclepias* from the Greek god of medicine, Asclepius, because of the toxic and medicinal properties of their milky latex, which bleeds copiously when the plants are damaged. The "milk" of some milkweeds is toxic, bitter, and nauseating because it contains heart poisons known as cardiac glycosides. The early correlation of poisonous foodplants of butterflies with their bright coloration and conspicuous behavior led to the hypothesis that butterflies are unpalatable to predators and derive their unpalatable chemicals from the plants. This is now known to be true for monarchs and some other groups of butterflies.



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research by American, English, Swiss, French, and German scientists, whose eventual chemical and biological assays elaborately supported the late 19th-century hypothesis of sequestration of plant poisons as the source of unpalatability in a wide array of insect species.

Since Walsh and Riley first called attention to the similarity of the viceroy to the monarch in 1869, it had always been assumed that the viceroy is a Batesian mimic. Jane Brower's studies showed that the viceroy was an effective mimic of the monarch but her data clearly indicated that it was less palatable than the control swallowtail butterflies. Indeed, in her 1958 paper in *Evolution*, she concluded that "the viceroy is not termed either a Batesian or a Müllerian mimic in the classical sense." But her long-awaited experimental proof that mimicry is effective so enthused the biological community that the preconception of the viceroy as a Batesian mimic of the monarch could not be swayed, and the two butterflies are figured in biology textbooks throughout the world as the premier example of Batesian mimicry. The subsequent discovery by Platt, Lincoln Brower, and Coppinger in 1971 that the closely related *Limnitis astyanax* was completely palatable to Blue Jays reinforced this general acceptance. After all, if *Limnitis astyanax* is a Batesian mimic of *Battus philenor* (Figure 7, right) then the viceroy, *Limnitis archippus*, must be a Batesian mimic of the monarch (Figure 7, left)!

It was not until 1991, when David Ritland, working on his Ph.D. in Lincoln Brower's laboratory at the University of Florida, finally resolved the question of the viceroy's mimicry status. Using wild-caught Red-Winged Blackbirds as the laboratory predator, Ritland showed that viceroys are sufficiently unpalatable to redwings that they must be regarded as Müllerian mimics; they definitely are not Batesian mimics of the monarch. Ritland compared the palatability of the viceroy with both the monarch and the queen. His experiments indicate that the mimicry relationships among the three butterflies are extremely dynamic. They depend on time of year and geographical locality where the monarch and queen are collected,

and on which species of milkweeds the queen or monarch ate as larvae. Queens frequently feed on non-toxic milkweeds in south Florida, and when they do they are palatable. Since the viceroy is unpalatable in its own right, these queens must be considered Batesian mimics of the viceroy, thus turning the historical assumption by 180°! Another of Brower's students, Alfonso Alonso, added a final flourish to the complexity: adult monarchs lose cardiac glycosides as they age, and thus become increasingly palatable, in effect going from model to mimic in their individual lifetimes.

As Steven Jay Gould pointed out in 1985, the viceroy's name indicates that it is the surrogate or vice-king, to the ruling monarch. In vogue with the current world democratization, it now seems that the viceroy has risen in unpalatability-power to rival the monarch. A recent article by Richard Vane-Wright of the British Museum in the prestigious London journal *Nature* referred to the historical view of the viceroy as a Batesian mimic as a remarkable case of self-deception in the scientific community. This theme was furthered in *Discover* magazine in a review entitled "Royal flush." And of course the creation biologists will interpret our finding as having disproven the whole of evolutionary theory. We see our promotion of the viceroy to the status of Müllerian mimicry and the varying palatability of monarch and queen butterflies as a marvelous example of the dynamic complexity that characterizes the real world of biology. A key question that now needs to be answered is what makes the viceroy unpalatable. It is clear that our elevation of the viceroy has shaken the monarchy in more ways than we ever could have imagined.

Lincoln Pierson Brower spent his childhood stalking butterflies and graduated magna cum laude from Princeton University in 1953 with a B.A. in Biology. He obtained a Ph.D. in Zoology from Yale in 1957, studied at Oxford University under a Fulbright Scholarship, and served as Chairman of the Biology Department at Amherst College before accepting a Zoology professorship at the University of Florida in 1980.

Dr. Brower has lectured widely about his research and other interests, which include ecology, evolution, animal behavior, and conservation biology. His current research is on the ecological chemistry, overwintering ecology, and migration of monarch butterflies. He has produced numerous documentaries on biology, and is author or co-author of more than 125 scientific papers, including seven articles to appear in *Biology and Conservation of the Monarch Butterfly*. This collection of papers, presented at the Second International Conference on the Monarch Butterfly, convened at the Natural History Museum in 1986 by Julian P. Donahue of the Entomology Section, will be published by the museum in 1992.

OPPOSITE ►

(11-14) Some of Professor Brower's experimental Blue Jays are shown here in a sequence that typifies the birds' reaction to unpalatable monarchs. First, a Blue Jay removes the monarch's wings. Then it prepares to swallow its body. After a few minutes, the bird begins showing signs of distress, including feather fluffing. Typically, within 10 or 15 minutes after one of the jays in the experiment had swallowed a monarch butterfly, the poisons that its caterpillar had ingested from the milkweed plant would begin to take effect, and the birds would become extremely sick. After a bout of vomiting like this, birds will no longer attack either monarch butterflies or the viceroy mimic.



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Reweaving the Threads of the Past

by Nancy J. Blomberg

DEEP IN THE HEART OF THE Los Angeles County Museum of Natural History, securely kept under lock and key and judiciously protected from destructive light rays, is one of the most extraordinary Navajo textiles ever woven. Created in the middle of the last century, this spectacular piece (which I came to call the Windway poncho for reasons outlined below) was part of a collection donated to the museum by William Randolph Hearst in 1942. Although I had studied it before, and knew that it had one of the most complex and unusual design combinations to ever come off a Navajo loom, its real significance had eluded me until recently.

While conducting research on the Hearst Navajo textile collection, I examined and re-examined each of the nearly 200 pieces Hearst had donated. Each piece was measured, threads were counted, materials were noted, and descriptions were made in painstaking detail from historical and aesthetic perspectives. Most of the objects were woven in the middle of the 19th century, and the overwhelming majority of design elements were standard: stripes, terraced triangles, rectangles, fretwork, and other geometric designs. Pictorial motifs were rare, and did not appear on any textiles woven before the 1880s and 1890s.

I had inspected this textile many times before, noting its layout and the complexity of its design, as well as the seven figures at the top. But as I examined it this time, I noticed that the strange, large hourglass-shaped figure at the top had very fine red and blue stripes woven in at the neck. My heart skipped a beat. These were crucial identifying characteristics of Holy People found in Navajo religion. It was extraordinary that the weaver would have included such a sacred figure in this textile, for this poncho was far older than any other known Navajo textile with such figures woven into it. The date attributed to it was between 1865 and 1875, yet distinct images of Holy People did not appear on textiles until the end of the nineteenth century — and this one was very, very different from those. The earliest documented example of a ceremonial motif in a Navajo weaving is 1883, in a blanket woven near Farmington, New Mexico, and it contains no recognizable Holy Person image. Furthermore, the best knowledge available until now would indicate that the depiction of sacred images in textiles was expressly forbidden in the Navajo religion during the period that this textile was created. If the date attributed to it was correct, it was the earliest appearance of a Navajo supernatural in a textile — or any other permanent medium, for that matter. What could it mean?

I was hooked. Even though more than a

century and a quarter had passed since this piece had been woven, I believed that there had to be a story behind it, and I was determined to unravel as much of it as I could. I knew that my chances were slim; it was a solitary piece among more than 500 Navajo textiles in the museum's collection, and there was very little documentation on it. But I was curious about this unknown weaver, and I suspected that the historical events around her that had shaped her life were coded somehow into this textile.

The mysterious weaver of the Windway poncho had used at least 16 different wool yarns that were native handspun, commercially plied, or raveled. The colors are predominantly white, red, and blue, and all dyes are vegetal in origin. The tightness of the weave is average for a Navajo blanket; this one has a centrally woven slit for wearing as a poncho. Both ends have wide blue borders, and two bold zigzag lines organize the design surface. They serve with the central diamonds as focal points for all the poncho's other elements: innumerable small rectangles, diamonds, triangles, and parallelograms organized in bands or clusters.

The largest and most significant figure is distinctively hourglass in shape, with triangular body parts composed of many small squares, creating a checkerboard effect. Stylized arms project upward from the shoulder area and hold multi-pronged objects. The head is rectangular, with simple brown eyes, mouth, and what appears to be hair. The upper portion of the face is blue and perhaps indicative of a mask. The neck has three or four horizontal stripes, three very narrow and one much wider, the latter a different color and made of different yarn. The waist area is bisected by a broad blue and red bar; two very short, diagonal bars protrude from beneath the figure.

Figurative elements are difficult to weave on the Navajo loom, so the inclusion of all of these figures was a deliberate act. Had the weaver seen something similar and was trying to emulate it? Or had she been influenced by trade goods that were the result of the Navajos' increasing contact with Spanish and Anglo merchants?

To answer the question of cultural "borrowing," I began a detailed comparison of the poncho with other textiles of the same period. More significantly, I began a thorough search of the literature explaining Navajo religion.

Navajo women have been weaving spectacular textiles on simple, upright looms for more than 300 years. During the period in which

OPPOSITE ►

The Windway Poncho. Depicting sacred images in textiles was expressly forbidden in Navajo religion during the period that this poncho was created, yet it contains what appears to be a Navajo Holy Person in the center at the top. The author's investigation of this anomaly led down a twisting trail of Navajo history culminating in the disaster at Bosque Redondo in 1863. The six smaller figures in the upper portion of the poncho have no specific characteristics of either humans or Navajo supernaturals. Some appear to be angels; some male or female humans. Whether they were intended to be Navajo, Spanish, Anglo, or other cannot be ascertained. Two small figures near the bottom could be profiles of highly stylized, seated birds. These elements were carefully crafted by an accomplished master weaver, but their precise identification, and their significance in the poncho, are completely unknown to the author.





When the author compared the large Whirlwind figure on the Windway Poncho with this figure from the Chiricahua Windway, she found striking similarities: upheld prayersticks, striped neck, and hourglass shape. Reprinted with the permission of the Taylor Museum of the Colorado Springs Fine Arts Center, Colorado.

this piece was made, the overwhelming majority of designs were geometric, with pictorial motifs incorporated only occasionally. The designs were created to enhance the image of the wearer and to be visually pleasing; there was no underlying meaning ascribed to them. Over the years, products of the Navajo loom, whether dresses, blankets, sashes, or rugs, were made as utilitarian objects, for Navajo consumption or for sale to others. With that understanding of the very secular nature of the Navajo weaving industry, we need to look to Navajo religion to see why the inclusion of a Holy Person figure in a textile is so extraordinary.

In Navajo ceremonials, referred to as Chantways, a broad pantheon of powerful supernatural beings, or Holy People, were called upon to maintain order and harmony. Each ceremonial involved an extremely complicated set of actions performed by the appropriate medicine man, called a singer. The singers used specific Chantways to invoke the assistance of specific Holy People. These Holy People were recognizable by certain distinctive features — such as the finely striped necks and generally elongated bodies. One place these figures appeared to the Navajo was in sandpaintings. Finely ground and colored sands were used by the singer to “paint” on the floor of the Navajo house or hogan a picture that included Holy People. Since tremendous power was present in these paintings, the images were always destroyed upon completion of the ritual. Any reproduction of these divine likenesses into a permanent medium such as a weaving was considered extremely blasphemous, for sacred images could not be carelessly transferred from a religious medium like a sandpainting to a secular one such as an article of clothing. Such an action was considered exceedingly dangerous for the weaver, moreover, and was expressly forbidden by Navajo religion. Small wonder, then, that such sacred motifs were rarely found in Navajo textiles.

Not until the late 1800s did Navajo weavers occasionally begin to include such figures in their work. Even then, holy images only appeared in non-sacred items generated specifically for trade, and they were made imperfect or incomplete to lessen the danger to the weaver.

The largest figure in the Windway poncho definitely has the striped neck of Holy People, but its body is hourglass-shaped, not the more typical elongated rectangle of other Navajo supernaturals. When I compared it with figures from a Navajo Chantway called the Chiricahua Windway, I found striking similarities.

The Navajo believe that the powerful winds that blow throughout their region are capable of causing them serious illness and great bodily harm. Wind Chants are therefore performed by

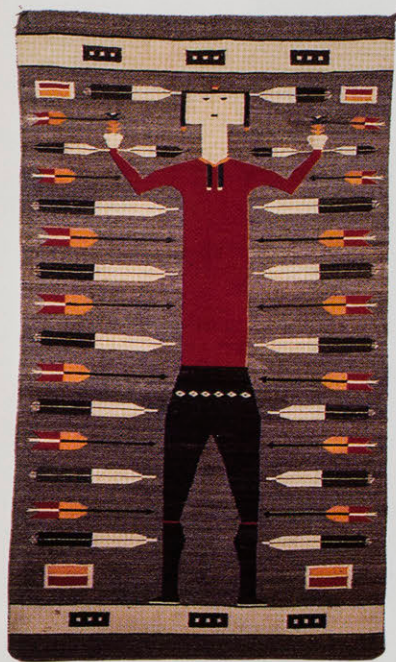
Navajo singers to cure any disease believed to be caused by the winds.

The Wind Chant ceremonial has two different components, the Navajo Windway and the Chiricahua Windway, the names indicative of their tribal origins. Historically, we know that the Navajo Windway predates the Chiricahua Windway. When anthropologists Leland Wyman and Berard Haile questioned Navajo singers in this century, all universally stated that the Chiricahua Windway originated at Bosque Redondo in the 1860s, when the Navajo and Apache were imprisoned together by the U.S. Government at a location near Fort Sumner, New Mexico. They all said that close contact between Navajo medicine men and Apache healers spawned the Chiricahua Windway and its addition to the Chantway system of the Navajo. Haile explains that before Bosque Redondo, the earliest and simplest version was known only as Windway, and thus had to be qualified by the word “Navajo” because of the new form, Chiricahua, developed at that time.

Unlike the elongated bodies of the majority of Navajo supernaturals, the bodies of the so-called Whirlwind People of the Chiricahua Windway are deliberately hourglass in shape — the result of stacking two triangles point to point. Furthermore, these holy figures are often depicted holding cactus prayersticks — the most important symbol of the chant — in their upraised hands. The large figure on the Windway poncho meets this description; it comprises two triangles placed point to point, and it holds multipronged objects very similar to the cactus prayerstick held by the Whirlwind Person on page 18. The distinctive shape of the large figure on the Hearst textile leaves little doubt of the weaver’s intention of creating a holy figure from one of the Windway Chants. For this reason I have called the textile the Windway poncho, and I believe that the holy figure is a Whirlwind Person.

The mid-nineteenth century was a time of great stress for the Navajo people. Years of warfare against Spanish and Mexican forces left a weary population. After 1846, U.S. troops began a campaign to control Navajo and Apache raiding parties. In 1863, soldiers of the U.S. Government, under the leadership of Colonel Kit Carson, intensified these efforts, and literally herded the Navajo and Apache from all over Arizona and New Mexico to Bosque Redondo with only the possessions they could carry on their backs.

The nearly five years spent in captivity at Bosque Redondo changed Navajo life forever. The Navajo way of life as nomadic raiders was swiftly erased, and a new settled life on the reservation began. Today, more than a century after their incarceration, Navajos still speak of their history in



This rug from 1910 shows the elongated body typical of Navajo supernaturals. The author wondered why the Whirlwind figure on the Windway Poncho, supposedly a Navajo supernatural, did not have this shape, but rather that of an hourglass. Courtesy University of New Mexico, Albuquerque, Maxwell Museum of Anthropology.



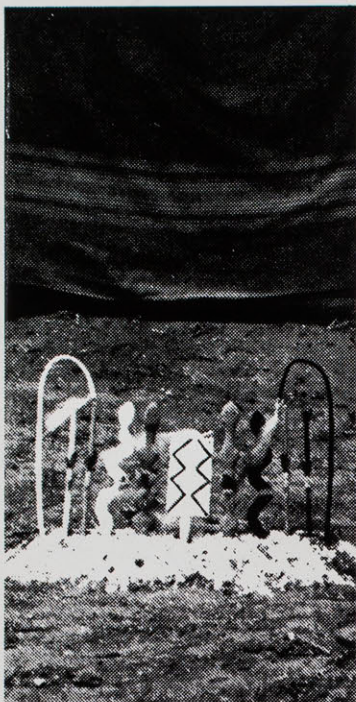
terms of before and after Bosque Redondo. The Windway poncho, crafted during this agonizing period of Navajo history, has a kind of visual pathology. Could its design be linked to the fragmentation of Navajo culture during the Bosque Redondo tribulation?

The portrayal of a Whirlwind figure in the Hearst poncho was very deliberate; its characteristic hourglass shape is quite distinct. But its relative obscurity within the surrounding design elements, and its location at the very top of the poncho — it was added at the last moment, just before the final border — are unusual. Evelyn Payne Hatcher's psychological analysis of Navajo art explains that an artist's placement of a small figure relatively high on a design surface correlates with a "lack of secure footing." Although such analysis is not always universally accepted in the anthropological community, it does support the notion of distress in the mind of the weaver, perhaps reflecting the Navajo idea of the tremendous danger of

permanent reproduction of sacred figures. The last-minute addition of the figure suggests that the weaver may not have wanted it to be visible on her loom for long.

When creating a design for any Navajo textile, whether blanket or rug, the weaver was fully cognizant of what it would look like during use. For instance, some Navajo blankets were woven with half and quarter diamonds at the edges, giving an appearance of incomplete patterning. But when worn wrapped around the shoulders, the diamonds joined in the front, completing the pattern. On the Windway poncho, all of the figures are placed so that they are upside down to people looking at the poncho, but right side up to its wearer as he or she looks down at them. (With two very different design fields, it seems apparent that the poncho was intended to have a back and a front, and we are assuming that the holy figures are on the front.) Could this be a code, a way of secretly preserving religion during the upheaval of Bosque Redondo?

Detail of the Whirlwind figure in the Windway Poncho. The striped neck was what first alerted the author to the possibility that the figure was a Navajo Holy Person.



The two vertical zigzags that run the length of the Windway Poncho resemble the renderings of lightning in this Navajo Chantway set-out. The lightning is painted on a particular kind of prayerstick — prayersticks are part of a singer's healing ceremony equipment — called wide boards. A set-out is an arrangement of prayersticks placed in front of the hogan, and is used as an offering by the singer performing the ceremony.

Reprinted by permission of the American Anthropological Association from *Memoirs of the American Anthropological Association*, 53-55, 1940.

Other noticeable features of this poncho could have been borrowed from elements in Windway sandpaintings, and they warrant mention. The stacked triangles in the end borders of the poncho could represent clouds or Cloud People, another category of supernatural beings from the Windways. Also, the two vertical zigzags in the poncho resemble renderings of prayersticks called wide boards, described by Clyde Kluckhohn and Leland Wyman in their authoritative work on Navajo Chantways. Wide boards bear on one side the image of a "wind supernatural," and on the other "two zigzag lightnings." Finally, near the upper ends of the vertical zigzags on our poncho are three seemingly erratic and unconnected lines. These are similar to the body markings of snake figures used in Windways.

The only record of a firm date for the Windway poncho is June 10, 1902. That is the date it was purchased by Herman Schweizer of the Fred Harvey Company Indian Department in Albuquerque, New Mexico, from Pedro Muniz, a native Mexican and itinerant merchant. Sometime in the next 30 years, the poncho was acquired from the Harvey Company by William Randolph Hearst, and then donated by Hearst to the Natural History Museum in 1942. How, then, can we be confident about when this piece was actually woven?

When lacking any original collection information, dates for Navajo textiles have been assigned by scholars on the basis of several characteristics, such as sources of yarns, chemical compositions of dyes, and comparison of designs and layouts with similar textiles whose dates are more certain. The predominantly white, red, and blue color scheme in the Windway poncho is characteristic of Classic Period serapes, documented from the 1840s to the 1860s. The geometric motifs of terraced triangles, diamonds, rectangles, and narrow-banded zigzags are also common in that period, although the extreme complexity and number of small motifs seen in the Windway poncho were more common toward the end of those years.

The vertical design format, central diamonds, end borders, larger size, greater length, and woven neck opening are uncharacteristic of Navajo textiles woven in the mid nineteenth century. They are, however, standard features of Spanish textiles produced by weavers in Saltillo, Mexico and the upper Rio Grande Valley of New Mexico. We know that the Navajo had increased contact with these peoples and their textiles during this time and that by the latter nineteenth century these new design features had begun to influence Navajo weavers.

Comparisons of the Windway poncho with a very famous Navajo textile, the so-called Chief White Antelope blanket, also gives a clue to the date of the Windway poncho. This blanket, woven by a Navajo, was collected upon the death of Chief White Antelope, a Cheyenne Indian, at the Sand Creek Massacre in southeastern Colorado in 1864. Both textiles share several distinctive characteristics rarely found in other Navajo textiles of that time period: dominant vertical zigzag motifs, large central diamond shapes, and bird figures. (The Chief White Antelope blanket has four small sitting birds woven in profile, admittedly more distinct than in the Windway poncho, but similar nonetheless.)

As mentioned earlier, 16 different yarns were used in the Windway poncho. This large number is not uncommon in textiles woven in the 1860s, when yarn shortages forced weavers use many different kinds of yarn to get enough of one color.

Dye analysis of the Windway poncho yarns was performed by David McJunkin of the Institute of Geophysics and Planetary Physics at the University of California, Los Angeles, using a technique called differential solubility, combined with solution spectrophotometry and spot tests. The results indicate that the poncho contains no synthetic dyes. Synthetic dyes were first invented in England in 1856, and began appearing in Navajo textiles by 1865.

During periods of warfare between Navajo and Spaniards in the 18th and 19th centuries, each side took captives and integrated them into their households as servants or slaves. Several examples exist of so-called slave or servant blankets, that is, pieces woven by Navajo women on Navajo looms using Spanish materials while living in Spanish households. According to Gladys Reichard in her 1936 book *Navajo Shepherd and Weaver*:

Many Navajo, some estimate three thousand, were slaves to Spanish and Mexican families of the Southwest. They were, furthermore, valued slaves. Women served more numerous in this capacity than men. The stories told of the weaving of the old blankets refer to the period when this subservience was at its peak (about 1830-1860). Families which valued their slaves at \$300 to \$400, were those which wore good clothes. They were the ones who furnished the elegant materials to their weavers.

If this piece was woven outside a Navajo community, the Windway figure on it probably was not understood by the weaver's captors. The Windway poncho, as noted before, has many Spanish characteristics, and the records of the Fred Harvey Company note that it was purchased from a Mexi-

can who traveled among the Spanish and Mexican families living in New Mexico.

Last, and perhaps most important for the dating of this poncho, is its association with the Windway Chants, for we know that the Navajo Windway predates the Chiricahua Windway, and all of the similarities between the poncho and significant features of the Chiricahua Windway clearly tie the Hearst textile to this Chantway and this time in Navajo history.

When I started this project, the date of the poncho was estimated by previous researchers to be around 1865 to 1875, based on late Classic Period designs and their layout, plus a suspicion that some of the pastel-colored yarns might contain synthetic dyes. Now, with the association with the Chiricahua Windway, the similarity to the Chief White Antelope blanket, and the results of the dye analysis revealing all vegetal dyes, the date should be revised backward to between 1860 and 1865 — the time of Bosque Redondo and just before.

Perhaps the Windway poncho was a commissioned piece, woven at special request. Weavers who produced such pieces in later years often did so because of the money promised by reservation traders. With the development of the Chiricahua Windway around the time of Bosque Redondo, it might be that the piece was a commemorative one, and that the inclusion of the sacred figure was an acceptable risk because it was so new to the Navajo Chantway system that it was unlikely to be widely recognized by other Navajos.

The most interesting speculation about the poncho's purpose also echoes the ordeal of Bosque Redondo. Its two distinct design fields are highly unusual for a Navajo textile, and it has been suggested that two different weavers may have worked on it. But design symmetry was the rule whether one weaver or ten worked on a piece, and this one, extraordinarily elaborate, is not symmetrical. However, the very center of the poncho has eight narrow horizontal blue stripes, four on each side of the wearer's neck. And when worn, the vertical zigzags appear to outline a large hourglass shape on either side of the poncho. Are these Windway correlates? Dare the weaver have intended that the wearer might actually assume the shape and characteristics of the powerful Whirlwind figure, as singer or as a person being cured?

Change in any culture is not a single event but rather a process stimulated both from inside and outside the culture. Certainly the increased contact with other cultures and the availability of new markets for their weavings influenced the materials and designs they would use. It should be expected that such massive discord as was generated by the Bosque Redondo experience would show

up in the important Navajo industry of weaving, and the Windway Poncho appears to be a striking example of this. Cross-cultural influences abound in it: its materials show access to manufactured goods, its design reflects Spanish and Apache influence, and its use of religious figures is original. Such evidence of change in progress is very rare, and to have so many forces captured, coded, and beautifully interwoven into a single textile is extraordinary.

Nancy J. Blomberg is Associate Curator of Native Art at the Denver Art Museum. Formerly a curator at the Natural History Museum of Los Angeles County, she authored the book Navajo Textiles: The William Randolph Hearst Collection and curated an exhibit of the collection in Los Angeles and Washington, D.C.

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The famous Chief White Antelope blanket, woven by a Navajo, shows characteristics similar to those on the Windway Poncho: dominant vertical zigzags, large central diamonds, and bird figures. This blanket helped the author date the Windway Poncho. Courtesy of the School of American Research, Santa Fe, New Mexico. Photograph by Roderick Hook.

The Segesser Hide Paintings

REVELATIONS ABOUT THE SOUTHWEST'S COLONIAL PAST

by Charles Bennett

TWO ASTONISHING ARTIFACTS from America's Spanish Colonial past were returned to New Mexico in 1986, after a 228-year sojourn in Switzerland. These artifacts, large paintings on bison hides, are known as Segesser I and Segesser II after the Swiss family that owned them, and are thought to be among the earliest depictions of colonial life in what is today the United States. They are certainly two of the earliest representations of armed conflict in United States history. Overall, the Segesser Hide Paintings can be counted among the most novel and important artifacts of Spanish Colonial history in the United States.

Each painting is composed of three bison hides sewn together. The subjects of the large paintings are armed confrontations between late 17th- and early 18th-century Spanish soldiers and their Pueblo Indian auxiliaries, and other, opposing Native American groups. In the case of Segesser II, the opposing Native Americans have the assistance of what appear to be European soldiers in 18th-century grenadier uniforms.

The two hide paintings were sent in 1758 by Father Philipp von Segesser von Brunegg, a Roman Catholic Jesuit priest stationed in the Province of Sonora, Mexico, to his brother Ulrich Franz

Josef, of Lucerne, Switzerland and were kept in the Segesser family for the next 200 years. The importance of the Segesser family paintings was first realized in 1945 by Gottfried Hotz, Curator of Ethnology of the North American Indian Museum, Zurich. Hotz wrote and published a book on the hide paintings that was translated into English and published in 1970 by the University of Oklahoma Press. Hotz's book was reprinted last year by the Museum of New Mexico Press under the title *The Segesser Hide Paintings: Masterpieces Depicting Spanish Colonial New Mexico*. In 1986, the paintings were loaned by the Segesser family to the Palace of the Governors, history section of the Museum of New Mexico, Santa Fé, and were purchased in 1988 by the State of New Mexico through private donations and an unprecedented legislative appropriation.

Segesser I, measuring 13½ by 4½ feet, portrays a confrontation between a group of mounted Native Americans, with two apparent non-Native Americans, and a large group of unmounted, opposing Native Americans. The setting is a forested, mountainous area, the habitat of the wild animals also depicted: bear, mountain sheep, buffalo, antelope, mountain lion, and others. The confrontation is thought by historians to be an ac-

tual event from the Southwest's colonial past, but there is uncertainty as to when the event took place. It is generally accepted that the confrontation took place during a punitive expedition dispatched from the Palace of the Governors, Santa Fé, against a group of Plains Apaches. The expedition consisted of Pueblo Indian auxiliaries and two Spanish military officers.

Native American groups, including Apaches, Navajos, Comanches, and Utes, raided the Spanish and Pueblo Indian settlements throughout New Mexico's colonial period (1598-1821). In retaliation, expeditions from Santa Fé, the New Mexico provincial colonial capital for a vast region that today includes much of the Southwest, were directed against these groups to punish them and inhibit future raids, and to rescue women and children who had been abducted. It is thought that Segesser I portrays one of the punitive forays that took place between 1696 and 1719. Research has yet to reveal the specific expedition.

There are at least three missing sections of Segesser I. According to family tradition, the largest missing piece, on the left side of the painting, was deliberately cut out in order to mount the painting over a window on a wall of Huenenberg Castle, a Segesser family home near Lucerne. Un-

fortunately, the fragment is probably lost. Another section of the painting, about 40 inches wide, showing a Native American tipi village, was evidently separated from the rest of the work sometime before 1908 and now belongs to another member of the Segesser extended family group. An offer has been made by the Palace of the Governors to purchase this section of the painting. A third segment also is apparently lost.

Much more is known about Segesser II, which is 17 feet long and 4½ feet wide. This hide painting depicts an attack of Native Americans and Europeans on a camp of Spanish presidial (garrison) soldiers and Pueblo Indian auxiliaries. The junction of two rivers is obvious on the right side of the work. Historians agree that Segesser II is a depiction of the 1720 destruction of the expedition of Spanish troops and Pueblo Indian auxiliaries led by New Mexico Lieutenant Governor Pedro de Villasur. The expedition reached the confluence of the Loup and Platte rivers, in present eastern Nebraska, when, in an early morning surprise attack, the expedition was virtually annihilated. The Villasur expedition had been dispatched by the Governor of New Mexico to seek evidence of French intrusion into what was at the time part of Spain's colonial empire.

The painted hide known as Segesser II.
From THE OLD WEST: The Spanish
West, photograph by Yves Debraine,
© 1976 Time-Life Books Inc.



Segesser I. The red, irregularly shaped masses behind the horsemen in this view of Segesser I are thought to represent hills. The striations at the top of the missing section of the painting are thought to be cliffs. These features, and the fauna depicted, imply that this encounter took place in mountainous terrain.



tion of trade with various Native American groups on a wider scale.

In the 18th century, the presence of the French in the West was a dominant force in shaping Spain's policy on her northern frontier. Actually, French presence in the West had been a concern of the Spaniards since the late 17th century. In 1673 Father Jacques Marquette and Louis Jolliet had descended the Mississippi River to the mouth of the Arkansas. Subsequently, Robert Cavelier, sieur de La Salle, made two explorations of the West, in 1681-1682, and in 1684-1687.

In the latter expedition La Salle set forth from France with four ships and 300 colonists with the objective of establishing a settlement at or near the mouth of the Mississippi River. For some unknown reason the expedition overshot the mouth of the river and ended up on the Texas coast at Matagorda Bay. There La Salle erected Fort St. Louis. After two years, during which his ships were destroyed and the colony significantly reduced in numbers and in grave need of supplies, he and some of his men started for Illinois. On the trip, the men, who were disheartened and insubordinate, murdered La Salle out of desperation. One of these men, 17-year-old Jean l'Archevêque, was later found living with the Caddo Indians by the Spaniards. He was taken to Mexico City, where he gave testimony on his involvement in the La Salle Expedition. L'Archevêque later relocated to Santa Fé, where he became a prominent merchant and progenitor of the New Mexican Archibeque family.

La Salle's expeditions opened the door to a true enmity between France and Spain in the trans-Mississippi West. Starting in the early 1700s, French traders traveled from Louisiana up the Red and Arkansas rivers toward New Mexico. In 1703 twenty Canadians left Illinois for New Mexico, to trade and investigate mines thought to be there. Between 1706 and 1719 French advances continued. In 1713 Louis Juchereau de St. Denis founded Natchitoches, on the Red River, and prepared to extend French trade to Mexico. Another Frenchman, Jean Baptiste Bénard de la Harpe, moving up the Arkansas River, proposed a post at the mouth of the Canadian River to trade with New Mexico. Word of French incursions on the Plains traveled among the Plains Indians, where it was picked up by Spanish expeditions. New Mexico's governors



in turn relayed the reports concerning French activity to Mexico City.

Throughout the first two decades of the 18th century, a series of expeditions was launched from Santa Fé, both to reprimand hostile tribes and to seek evidence of French trespass. As mentioned, one of these expeditions is thought to be the subject of Segesser I. Eventually, reports of French activity in Texas, coupled with New Mexico's already existing problems, convinced the authorities in Mexico City that decisive action had to be taken to stop French incursion into Spanish territory. In a plan devised to establish dominion on the Plains in the face of French expansion, Spanish Viceroy Baltasar de Zúñiga, Marqués de Valero, directed New Mexico Governor Antonio Valverde y Cosío to establish a fort at a place in western Kansas near the present Kansas-Colorado boundary.

Governor Valverde was well aware of the implications of French intrusion; however, he was not convinced of the prudence of locating a fort so far from Santa Fé at the place specified by the viceroy. While acknowledging the viceroy's directive, he organized an expedition to punish a Comanche group that had recently raided some New Mexican settlements. While on the Plains, that expedition would seek evidence of French activity. Further, Governor Valverde would compile more information questioning the judiciousness of locating a military post at the place enumerated by Viceroy Valero.

In 1719, Governor Valverde departed Santa Fé with 60 garrison troops, 40 civilians, and 465 auxiliary Pueblo Indians (the Spanish had long relied on indigenous allies to augment their own military forces). As expected, irrefutable evidence of French presence on the Plains was found on this expedition. Once back in Santa Fé, Governor Valverde convened a council to consider the viceroy's instructions in light of the new evidence. Meanwhile, word was received from Madrid that a state of war had been declared between France and Spain. With the subsequent loss of Pensacola, Florida, to France in 1719, the viceroy became convinced of a mounting French military threat on the Plains. New Mexico needed to act.

In spite of the critical situation, Governor Valverde and his council could not agree with the viceroy's instructions regarding the establishment of a military post at a remote place on the Plains. It was subsequently decided that yet another expedition was in order, to reconnoiter a better place for a fort, and to learn of any new French intentions among the Plains tribes.

In mid-June 1720, Valverde dispatched this expedition, under the leadership of his lieutenant governor, Pedro de Villasur. Forty-eight royal troops and three civilians including expatriate Frenchman Jean l'Archevêque, now known as Juan Archibeque, were in the party. Archibeque was the expedition's translator, since the Spanish fully expected to find Frenchmen. Additionally, 60 armed

These two errant segments of the Segesser I Hide Painting were purchased by the Palace of the Governors of the Museum of New Mexico along with the rest of the work. They were originally to the immediate right of a 40" piece showing a Native American tipi village; this piece was separated from the rest of the painting before 1908 and is in the collection of another member of the Segesser family. Another piece, the extreme right side of Segesser I, with the decorative border, is missing.





Segesser II. The chaplain of the Villasur Expedition, Friar Juan Minguez, can be seen running toward the group of Spanish presidial soldiers fighting back-to-back in the photo opposite. The priest is depicted in the traditional blue cassock of the Franciscan Order in New Mexico in the 18th century. Tonsured and bearing a crucifix, he is portrayed holding his robe over his head to enable him to run faster, and perhaps in a feeble attempt to protect himself; he has received several arrow wounds.

and mounted Pueblo Indian auxiliaries accompanied the royal troops. The leader of the auxiliaries was Joseph Naranjo, a Pueblo Indian from a village north of Santa Fé. Naranjo, who was assigned the prestigious title of *capitan mayor de guerra*, is thought to be one of the individuals portrayed in the battle scene of Segesser II.

The expedition headed north from Santa Fé to Taos, turned east, then northeast into present-day Kansas. Then, following a Pawnee route to the Platte River (Río de Jesús María), the group moved north into eastern Nebraska. They followed the Platte east to the Loup River (Río San Lorenzo), where they found evidence of a large Native American village on the move. The expedition proceeded up the Loup until it came to a large Pawnee Indian encampment. Villasur tried to open dialogue with the Pawnees, but to no avail. When he heard that a white man was living among the Pawnees, he attempted to contact the man with a letter written in French by Archibeque. Again, there was no answer.

Sensing a potentially hostile situation, Villasur ordered his army to retreat to the confluence of the Loup and Platte rivers, where the men set up camp on a plain covered with tall grass. At daybreak the next day, August 13, 1720, the Pawnees and a group of their Oto Indian allies attacked. They caught the New Mexicans completely by surprise. The Indians' initial onslaught apparently in-

cluded some musket shots. A pitched battle ensued in which all but fourteen of the Spaniards were left dead in the tall grass. Villasur, Archibeque, and the expedition's only priest, Fray Juan Minguez, all died. Captain Joseph Naranjo was among the 11 Pueblo allies who were killed in the affray.

The attack was a major catastrophe for New Mexico. The casualties amounted to a third of the province's best soldiers. The loss of the 11 Pueblo Native American auxiliaries was to be felt for a generation or more in the villages from which they hailed. A former governor, Félix Martínez, who was Governor Valverde's rival and antagonist, wrote to Viceroy Valero:

... in the villa of Santa Fé, thirty-two widows and many orphaned children, whose tears reach the sky, mourn the poor ability of the governor, pray God for his punishment, and await the remedy of your justice.

Former Governor Martínez was already in Mexico City facing various charges resulting from his term as governor. He attempted to place the blame for the debacle on Governor Valverde. The result was a series of reports and interviews. Valverde defended Villasur, whom Martínez accused of incompetence and inexperience. The investigations continued for the next seven years.

The lengthy investigation culminated in a mild reprimand for Governor Valverde. He was ordered to pay 50 pesos towards Catholic masses for the souls of the dead soldiers and 150 pesos for purchases of a chalice and ornaments for new missions. The same order absolved him of guilt for his judgement in directing Villasur to lead the expedition.

The only extant eyewitness account of the expedition is a portion of a diary kept by Corporal Felipe Tamarís. The diary was found at the scene of the attack by Oto Indian combatants and was turned over to Pierre Dugué de Boisbriant, commandant of the Kaskaskia outpost in the French district of Illinois. It was translated from Spanish into French in the 1720s. The translation is in the Archive Nationales in Paris, but Tamarís's original diary cannot be found. The last entry in it was made the day before the attack. The most reliable accounts of the attack were given by the Spaniards who survived. Commander Yldefonso Rael de Aguilar gave testimony during the investigations, as did Corporal Tamarís and two other survivors. Unfortunately, the Tamarís diary, his testimony, and that of the other survivors is imprecise on certain points.

It has been asserted that the 37 Europeans firing longarms at the Spanish troops in Segesser II are French soldiers. A perplexing question is whether French soldiers were actually

present at the dawn attack on the Villasur expedition. There is no record of a French military contingent in the area of the confluence of the Loup and Platte rivers, where the attack took place (near present-day Columbus, Nebraska). A volley of musket fire was reported by several of the survivors. But Corporal Tamarís testified that he did not know who the attackers were, presumably because of the resulting confusion of the surprise attack and the tall grass that hindered visibility. The other survivors were equally uncertain as to the identity of the attackers. The present assumption is that if there were any Europeans present in the attack on the Spanish troops, they were most likely French traders. At the very least, the musket fire could be considered deadly proof that the Pawnees and Otos had obtained firearms from the French. French reports of the attack, all secondhand, are confusing and conflicting, and do not reveal any new information, although the French were intrigued over the disaster and embroidered upon the story as Spanish guns, edged weapons and clothing articles, and the Tamarís diary were brought in by various Native American groups to Michilimackinac in Michigan, and to locations in Illinois.

In terms of art history, there are many precedents for the Segesser Hide Paintings. Large wall hangings were popular in Europe and Mexico in the 17th and 18th centuries. Known as *reposterios* in Spanish, these wall hangings typically featured biblical, mythical and battle scenes, and floral patterns. In Europe most wall hangings of this period were tapestries, produced in factories in various countries such as Belgium and France.

In the New World these wall hangings were also executed on leather. The use of leather for such wall hangings was itself not unusual, as the Moors had a tradition of painting on leather that the Spanish inherited and brought to Mexico. In New Mexico, religious figures were painted on animal hides and used by the Franciscan missionaries as decorations for ecclesiastical structures in the conversion of Native Americans to Christianity.

It is generally conceded that the Segesser Hide Paintings were painted on leather because canvas would have been a rare commodity on the northern frontier of New Spain. Today there are 68 hide paintings extant from New Mexico's colonial period in museum collections, although none of them are as large as the Segesser Hide Paintings, and all are of strictly religious subjects. In New Mexico, and probably in other places in New Spain as well, painting on hides can be considered a frontier solution to the unavailability of canvas.

It is believed that the Segesser Hide Paintings were painted in New Mexico, likely in Santa Fé. Again, there is an historical precedent for



this assumption. Tanned hides were an export item throughout the colonial period in New Mexico. Hides were acquired through trade from the Plains Indians, and processed by the Spanish colonists. They were used for clothing and bedding by both Native Americans and Spaniards. Historical documents mention that *reposterios* were also being produced in "factories" in Santa Fé, one of which was owned and operated by a colonial period governor. In these factories Native Americans produced painted wall hangings for export to Mexico; it is very likely that there was a market for them in the mining towns of northern Mexico. The documents indicate that hides were painted in Santa Fé and

Detail of the battle scene in the Spanish camp, Segesser II. The group of presidial soldiers is illustrated, wearing traditional wide-brimmed hats and sleeveless, multi-layered cowhide jackets (*cueras*), and bearing lances, muskets, and shields. The hatless man with blond hair and a blue coat on the right side of the group is thought by some historians to be Juan Archibeque (Jean l'Archeveque), interpreter for the Villasur Expedition.



One of the most important French geographers and cartographers of the 18th century was Guillaume Delisle (1675-1726). In 1718 Delisle published his celebrated "Carte de la Louisiane et du Cours du Mississippi," which embraced the western country as far as the course of the upper Rio Grande.

The Delisle map was reissued many times with only slight changes during the remainder of the 18th century by most of the leading cartographers of Europe. Apparently Delisle obtained much of his information directly from the French explorers and administrators in New France. His efforts represented distinct advances in the mapping of the American West.

exported to other areas in New Spain throughout the colonial period.

The Segesser Hide Paintings do not show any distinctive ground or gesso layer under the paint. The colors seem to be of local organic origin, except in the case of the dark blue paint, which has been identified as Prussian Blue, a commercial pigment produced in Europe. This blue pigment appears to have been mixed with yellows to create some of the greens. Time has muted the once-brilliant colors of the Segesser Hide Paintings, but the viewer can discern the vibrancy of the original pigments in examining Segesser I. This painting appears to have been mounted at one time with molding strips covering several narrow vertical bands of the work and protecting them from light degradation.

There seem to be at least two distinct styles present in each of the paintings. Based on the fineness of line, it seems likely that the human figures may have been drawn by one hand, the floral and faunal details added by another, and the floral borders done by yet another artist. Multiple artists were definitely employed in the factory-setting production of *reposterios*; thus it seems likely that this was the approach taken with the Segesser Hide

Paintings. In the case of Segesser I, it seems probable that an eyewitness assisted the artists in their execution of the paintings by providing details of the disaster, since the imagery in the paintings closely coincides with recorded accounts of the attack.

Further research is being conducted on the Segesser Hide Paintings as they are sought out by scholars for the insights they provide to the study of ethnography, armament, clothing, horse gear, social stratification, European and Native American alliances, Native American panoply of the period, the European rivalry for the trans-Mississippi West, and other factors. Future analysis is planned, to locate the hides, in terms of their preparation, within Native American or European technology. Further testing, it is hoped, will determine the specific organic nature of the pigments.

Historical documentary research is also continuing. The ship used to transport the paintings to Europe has been identified, and the vessel's cargo manifest has been found. In one of his letters home, Father Segesser mentions having shipped three paintings. This third painting is unaccounted for, but research is currently being conducted along two propositions. The first is that the captain of the



The confluence of the Loup and Platte Rivers is depicted in this view of the left side of Segesser II. French soldiers with muskets are illustrated, leaving the scene of the attack on the Villasur Expedition. The implication is that the French soldiers and their Pawnee and Oto Native American allies came from a village situated upriver.

ship, Domingo Apodaca, or his uncle, Tomás Apodaca, the ship's owner (both residents of Cadíz, Spain, where the ship docked after the voyage from Mexico) kept the third painting as a curiosity or as payment for transporting the crate containing the paintings to Europe. Unfortunately, at the present time there are no members of the Apodaca family residing in Cadíz, although the main street of the city is named Avenida Apodaca. According to local sources, the family relocated to the Jerez region of southern Andalusia, Spain. Efforts are being made to locate Apodacas living there, to see if family members possess any information on the missing third painting.

The second proposition being investigated is that all three hide paintings arrived in Switzerland, where the third painting was given to the Balthasar family, based like the Segesser family in Lucerne. The Balthasars also had a son serving as a Jesuit missionary in Sonora who was a close friend of Father Segesser. Inquiries about the third painting have been made of family members still residing in Lucerne, but until such time as this painting surfaces, if in fact it still exists, one can only speculate as to its subject matter and what it could reveal to researchers.

Another critical question addressed by scholars but not definitively answered is why the paintings were executed. Were they decorative *reposterios*, leather tapestries, intended like their European counterparts as adornment and warmth-retainers for the room of a private home or public structure? Were they intended as visual aids to accompany the official reports of the events they portray? It is assumed that Father Segesser acquired the hide paintings in Sonora between 1732 and 1758. But how did the paintings get to Sonora? A likely explanation is through the Anza family. For generations beginning in the late 17th century, members of the Anza family were prominent in the military and civil affairs of both Sonora and New Mexico. An Anza family home was located in the same village where Father Segesser's mission was situated. It is known that members of the Anza family were on friendly terms with the priest. One of the Anzas may have brought the three hide paintings to Sonora, where they became the property of Father Segesser.

The paintings have great public appeal. In addition to their scholarly significance, they have the dramatic impact of a frontier battle, and they graphically illustrate the violence and political com-

plexity of life in early America. Since they were placed on exhibit in the Palace of the Governors in August of 1986, an estimated 836,000 people have viewed them. Now a permanent part of New Mexico's patrimony, the Segesser Hide Paintings are a true source of pride for all New Mexicans.

Charles Bennett has been a member of the research team investigating the Segesser Hide Paintings from the outset. He is currently Assistant Director and Curator of Collections, Palace of the Governors, Museum of New Mexico. His specific area of research is the Americanization of the Southwest: the process whereby the laws, institutions, and customs of the U.S. were superimposed on New Mexico and the Southwestern Borderlands beginning in 1821 with the opening of the Santa Fé Trail.

Unless otherwise noted, all photographs are by Blair Clark, and are courtesy of the Palace of the Governors, Museum of New Mexico, Santa Fé.

The editors thank René Chartrand of the Canadian Parks Service for his contributions to collateral material about weapons and uniforms in this article.

A French View of the Massacre

Gottfried Hotz, the Swiss scholar who spent 25 years studying and analyzing the Segesser hide paintings, concluded that the uniforms that the soldiers were wearing could not identify them as French or anything else. He further states that when questioned by Governor Valverde about French presence a year before the massacre, the Indians "soon realized what interested him most and exaggerated the rumors about the French." Gov-

ernor Valverde, Hotz points out, may have had an interest in producing a picture of the massacre that involved a large number of Frenchmen; since he was held responsible for the disaster, an eyewitness painting that supported his contention of French incursion — and thus justified his decision to mount the Villasur expedition — might have helped exonerate him.

So far, the fascinating saga of the Segesser hides has been pieced together from information gathered in Switzerland, Santa Fe, Mexico City, and Spain. It may be, though, that the most fruitful avenue for future research is in records of the French regime of the early 1700s.

For example, on July 1, 1722, Nicolas-Michel Chassin, agent for the Company of the Indies, which controlled Louisiana under French charter, reported on recent events to the Minister of Marine in Paris. Some five months previously, he recounted, a French *voyageur* (or trader) returned from the country of the Otos and the Kansas to the French Illinois post with news of a severe defeat of the Spaniards at the hands of allied Indian tribes. One of the chiefs, the trader said, gave Commandant Pierre Dugué de Broisbriant a chasuble and a chalice that had been taken from the field of battle; one of the Spanish casualties had been the chaplain, Fray Juan Minguez.

This bit of information in

Chassin's letter is relevant for several reasons. For one, Broisbriant, who was leader of the new French posts in the Illinois country with only a few dozen soldiers, apparently knew little or nothing of the encounter. It is hard to imagine that there would have been French military involvement in the massacre without the knowledge of the superior officer. Also, Chassin's report helps establish the presence of French traders at the battle; even if French military forces were not there, the traders were, and they may have participated. Still, none of the existing reports say who was doing the shooting, and the artist of the hides seems to have depicted some rather generic Europeans.

Most importantly, the Chassin document verifies the encounter and indicates some of the participating Indian groups.

This particular document is in *Archives des Colonies*, Series C 13 A, Vol. 6, folios 297-300. There are tens of thousands of French letters, reports, and other documents from that period in the commissary, military, church, land, and other records of the French regime for that era of Louisiana-Illinois Country history. Volumes I-III of the *Dictionary of Canadian Biography* (Toronto, 1966-1974), contain brief sketches of major French frontier personalities, and provide the handiest lists and explanations of sources that could shed further light on the

French point of view regarding the Villasur expedition. It may well be that this unusual Spanish penetration into the heartland had additional repercussions in trade, military planning, or Indian affairs. The *Archives des Colonies*, available in several depositories in Louisiana and in the Public Archives of Canada, may prove to be fertile ground for the next round of discoveries about the enchanting Segesser hides.

DONALD CHAPUT
Curator
History Division



A French hunting and trade musket, circa 1720. The butt is damaged, but the musket still has the original flint lock. These muskets were made in Tulle and exported to the colonies. Light and sturdy, they were very popular with Indians and traders.

A unique French musket for colonial troops, made at Tulle, France about 1697. This type of musket was used into the early decades of the 18th century.

This portion of Chassin's 1722 report provides news of the defeat of the Villasur expedition and of the chaplain's paraphernalia found on the battlefield.



Encountering the New World, 1493-1800

by Susan Danforth

OPPOSITE RIGHT ►

An indigenous American art form, *santos* are carved wooden sculptures or portraits painted on wood representing the saints, the Holy Trinity, Christ, the Madonna, and the Holy Family. The figure shown here probably depicts Our Lady of Sorrows, supported by two cherubs. Most *santos* date from between 1750 and 1850.

OPPOSITE LEFT ►

Sundials are normally designed to be used at a particular latitude. Pocket dials had to be manufactured so that a traveler could adjust them to tell accurate time at different locations. The face of the round equatorial sundial could be moved to match the latitude of the user's location. The folding vertical and horizontal dial has a string gnomon that could be repositioned for use at different latitudes. For the convenience of the user, portable dials often had the latitudes of major European cities engraved or printed on their backs.

SOMETIME DURING AN INTERLUDE of good weather on the return from his first voyage to America, Christopher Columbus composed a short letter about what he had found. This document, something like a modern press release, described the marvels that he had seen, downplayed negative news (such as the loss of his flagship the *Santa Maria*), and omitted details, such as course headings or distances, that might help competitors. Forced by storms to put into Lisbon, Portugal, Columbus sent this announcement of his discoveries overland to the Spanish court. The document, which soon found its way into print, helped spread the news of Columbus's voyage across Europe.

The publication of the now famous *De Insulis Inventis*, or Columbus Letter, represents the convergence of two developments that changed the world — the invention of printing and the European discovery of America.

It is now accepted as a truism that Columbus did not discover America. We know that Norsemen temporarily colonized Newfoundland as early as the 11th century and that the true discoverers were Native Americans who crossed over from Asia at least 12,000 years ago. Even so, from

the European point of view, Columbus deserves the title Discoverer because his voyage opened a world previously unknown to the Western mind. The existence of the Americas challenged many long-held notions about geography, the natural environment, and the nature of the human race itself. Gutenberg's invention of movable type in the mid-1400s made it possible to disseminate this knowledge much more rapidly and to a much wider audience than ever before. The new printed books with pictures and maps, woodcuts, engravings, and etchings helped satisfy the Europeans' growing curiosity about the world that Columbus's voyage opened to them.

How European perceptions of the New World changed over a 300-year period is well documented in *Encountering the New World, 1493-1800*. This exhibit, from the John Carter Brown Library in Providence, Rhode Island, contains nearly 200 prints, maps, and illustrated books from that library's unequalled collection of materials that relate to the discovery, exploration, settlement, and development of the Western Hemisphere.

Columbus's letter to the Spanish court caused Europeans to realize that the perimeters of their world were changing. As details of the discovery were gradually disseminated, certain old theories and legends were abandoned: reality was even more astounding than the fruits of the medieval imagination. On the other hand, other fables, prophecies, and notions seemed to be coming true. It became ever more apparent that pictures were needed to emphasize the novelty of the New World experience and to make it understandable.

Challenged by the discovery, cosmographers, philosophers, and members of the church began to reevaluate their concept of the world and to ask basic questions about themselves in relation to the new order of things. Over the centuries that followed, European governments and entrepreneurs debated questions such as: Who are the rightful owners of American land? By what right does one exploit peoples and resources? How are overseas empires to be managed?

Europe's encounter with the Americas was the first event of world-altering importance that had the appropriate technology in place to disseminate information about its many facets. New and quickly developing methods of printing and copperplate engraving joined with the older woodcut tradition to provide an eager public with a multitude of images that enhanced and expanded the impact of the printed word. This visual reporting was accomplished by means of maps and prints that showed the audience at home the places where things were happening, the peoples that were being encountered, and who the heroes and the villains were.



Dick Meier

This Culpeper-type microscope is named after its inventor, Edward Culpeper (1660-1730). Matthew Loft manufactured this particular model at "the sign of the Golden Spectacles behind the Royal Exchange, London." Yale University purchased a microscope identical to this one in 1734.



Excitement and confusion were integral parts of the process of coming to terms with the unexpected. Walled European cities and oceans filled with monsters set the stage for a European view of the world on the eve of the "Discovery." A simple woodcut from the first illustrated Columbus letter of 1493 purports to show the mariner's landfall in the West Indies and his greeting by the native inhabitants. Other popular books show "true" pictures of dog-headed cannibalistic American natives and strange American giants.



The presence of unexpected New World peoples placed considerable strain on accepted ideas of world order. During this early period European artists, cast visually adrift and often dependent upon hearsay, incorporated the Amerindians as best they could into a traditional imagery that had always confined strange beings to the outer fringes of the known world. Lively debate arose among religious scholars who questioned whether or not they were human and what the responsibility of "civilized" man was toward them. This ambivalence is shown in this depiction of Amerindian "savages" who, although they are shown obliging the Spanish invaders' thirst for gold by pouring the molten metal down their throats and engaging in cannibalism, are drawn with European faces and bodies — a tangled attempt to invest them with "humanity."



Developing geographical awareness led to attempts by European scholars to integrate conflicting information into a revised view of the world. Geographical relationships between North and South America, Asia, and Europe varied greatly as different stories came back and as mistakes were copied by successive cartographers. This 1507 map was one of the earliest to identify the emerging New World landmasses with the name, "America."





In order to eradicate what was viewed as “paganism” or “devil worship” in Christian eyes, and replace it with the Catholic religion, Spanish priests did their best to destroy all vestiges of Aztec

religious life and customs. As time went on, they suspected that remnants of the old ways persisted, but without a guide to the past, they were helpless to intervene. The Mexican-born Jesuit Juan Tovar was charged with writing a history of the Aztec people and their customs (c. 1585). His text is accompanied by vividly colored images, possibly painted by an Indian, but even in this act of remembering, there is evidence that much was forgotten in the half-century since the conquest. Many of the symbolic relationships between Aztec color and design, for example, have become confused in the paintings. In one, Montezuma is shown with a Cortés-style beard.



Samuel de Champlain, best known for his Canadian explorations at the beginning of the seventeenth century, made an earlier voyage to the West Indies. The manuscript account of the Spanish-held Caribbean islands and Mexico (c. 1599-1600) that has been attributed to him is filled with watercolor maps and pictures of indigenous plants and animals. The artist (assumed to be Champlain) had not actually seen all of the animals he depicted, and some of the strange beasts that inhabit the pages owe more to European mythology than to actual observation.

THE JOHN CARTER BROWN LIBRARY

The exhibit *Encountering the New World, 1492-1800* has the distinction of being drawn entirely from the collection of the John Carter Brown Library on the campus of Brown University. Utilizing three centuries of maps and prints, the exhibition offers a panorama of New World imagery as seen through the eyes of the Europeans who encountered, explored, and settled themselves upon the two continents that unfolded to the west.

These tools for scholarly research were originally designed to attract the eye, underscoring the importance of visual information to a population that could not read. They also show the particular rubric under which artists and designers worked to communicate with their communities, and the ways in which the presentation of American topics changed through three centuries.

The "context" of the material begins to reveal itself as well — to whom were these pictures directed? who bought them and why? Some show signs of much use, while others are pristine as if no one had ever turned the page or handled the sheet of paper. Some are enhanced by color. Others stand unadorned in black and white. From the artistic to the utilitarian, the simple to the complex, these images often reveal as much about the attitudes and cultural assumptions of their makers as they tell about the things they depict.

John Carter Brown of Providence, Rhode Island, who began decisively to collect books about America in 1846 at the age of 49, was interested in how the world he lived in had

come to be. An admirer of Old World traditions, Brown focused upon European voyages and travels as well as books that provided a background for broader issues of westward expansion.

Although his cultural perspective was Eurocentric, as was typical for the time, John Carter Brown's approach to building a collection diverged significantly from the usual profile of the wealthy American or European book collector. Instead of amassing books primarily as objects of art, Brown was gathering together his books as ideas. In his library, the great "cornerstone" pieces of Americana shared shelf space with virtually unknown supporting texts. The texture and depth provided by this combination added a new dimension to Americana collecting. In their letters to one another, John Carter Brown and the antiquarian bookseller Henry Stevens of Vermont called it "The Great Subject."

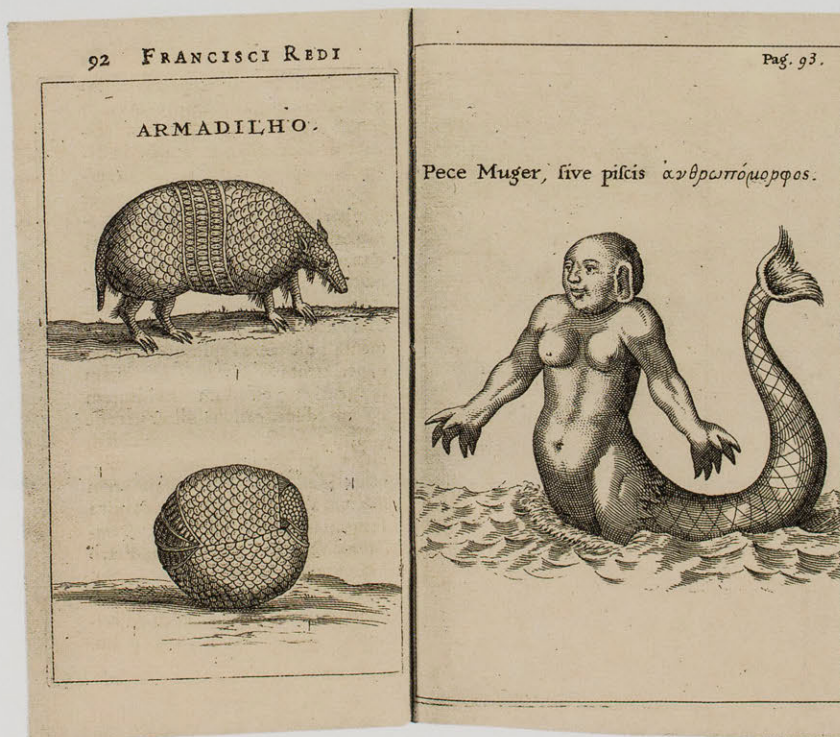
And a great subject it has turned out to be, if such things can be gauged by the level of popular and scholarly debate. Although attitudes about the world and our place in it have undergone significant change since John Carter Brown started his library of Americana, the collection he began has retained its focus and has continued to grow. This continuity of purpose has provided generations of scholars with the original books, maps, and prints they need to explore the past and to question long-held assumptions about how we got to where we are today. The fruits of this ongoing process of discovery we are witnessing now in the challenges of lively Quincentennial debates.





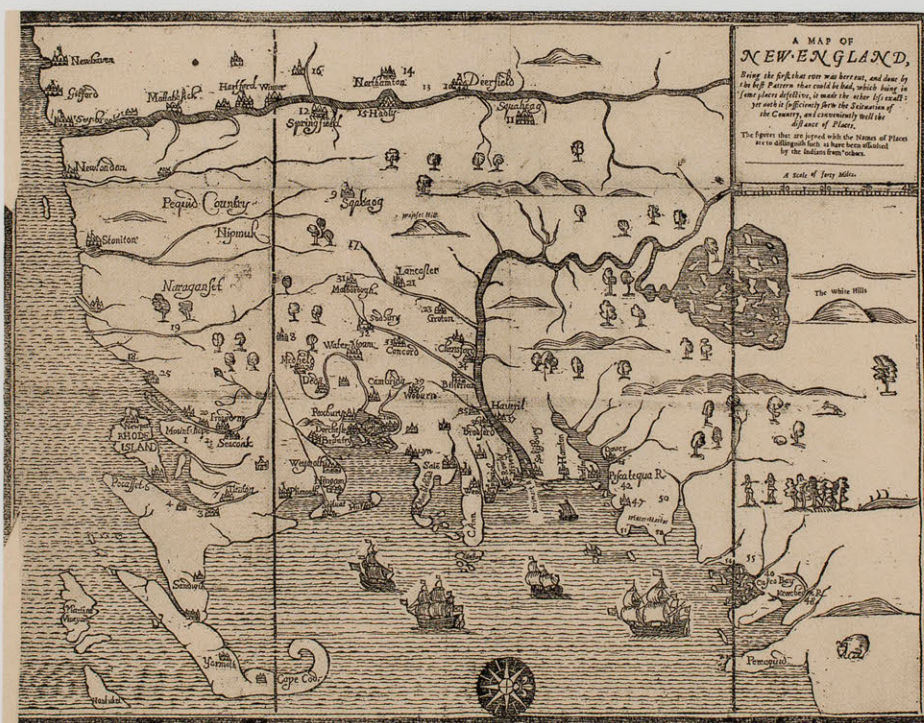
In the 18th century, Mark Catesby, an English naturalist and traveler, strove to provide a complete and accurate visual record of the flora and fauna of the southeast of North America and the Bahamas in his *Natural History of Carolina, Florida, and the Bahama Islands* — two folio volumes with some hundred plates.

The lush tropical landscape and odd-looking creatures continued to fascinate European audiences. Medicinal uses were found for both real and imaginary animals. Francesco Redi, in his *Experimenta circa res diversas naturales* (Amsterdam, 1675), suggested that the bones of the armadillo's tail could be ground into a powder and used as a painkiller. Mermaids from the coast of Brazil reportedly had "tender bones, which promote chastity, inhibit carnal desires, render men impotent, and are useful in many other ways for the good of the body."





Very few explorer/adventurers made on-site drawings from life to accompany their narratives. The usual practice was for artists and engravers in Europe, who had never been to America, to conjure up appropriate illustrations for the text. Notable exceptions were Jacques Le Moyne de Morgues and John White, whose sketchbooks supplied the Dutch Protestant Theodor De Bry with on-the-spot observations of the peoples of Florida and Virginia, respectively. Nevertheless, much anthropological detail was distorted in the process of translating these drawings to engravings for wide distribution, giving the impression that North America was populated by Greek gods, rather than by human beings. Native peoples were sometimes presented as childlike, sometimes as amoral and threatening.



The increased European activity in North America multiplied the possibilities for conflict. Confrontations between the newcomers and the Amerindian societies they began to displace, and between European nation states vying for supremacy on new soil were an ever-present part of life in 18th-century North America.

The first map to be drawn, cut, and printed in America, is a “news map” dotted with battle sites (1677) of what the English colonists called “King Philip’s War.” This was the final, desperate attempt by southern New England Indians to maintain a hold on their homeland.

The visual record of the harsh exploitation of Peruvians and their silver by the conquistadors was supplied in dramatic fashion by De Bry, who had no love for Spanish Catholics. His series of illustrated European voyages to the East and to the West, published in the late sixteenth and early seventeenth centuries, were responsible for disseminating throughout Europe the “black legend” of Spanish cruelty in the New World.

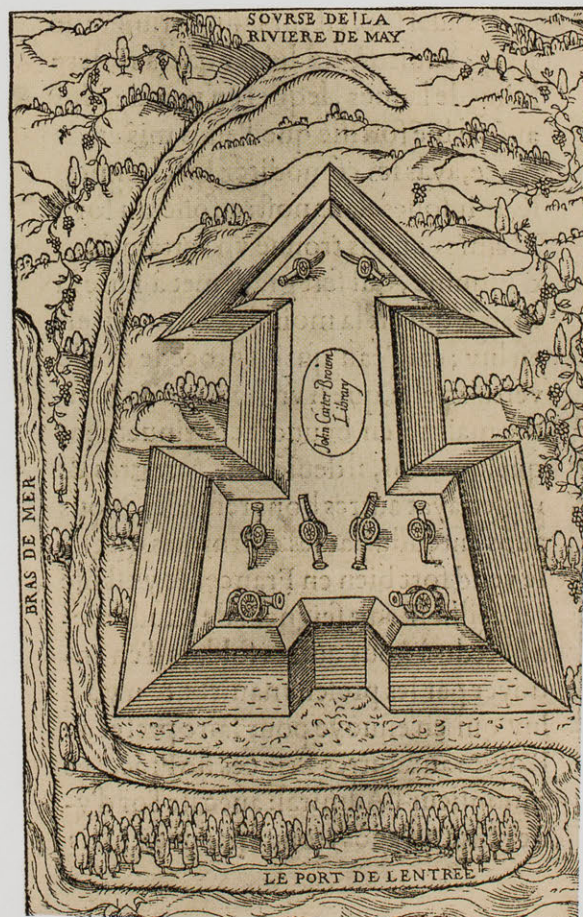
On the other hand, the Spanish view of their place in the sixteenth-century world is found in the John Carter Brown Library’s treasured manuscript atlas by the Venetian cartographer, Battista Agnese. This world map from the atlas depicts the circumnavigation of the globe by Magellan, and picks out in gold the route the Spanish treasure fleet used to bring New World riches to Spain. This was a sixteenth birthday gift from Emperor Charles V to his son, who would become Philip II of Spain. The unspoken assumption? “This world is yours.”





Many and varied were the struggles between European nation states for ascendancy in North America. Buccaneers, who were often the human debris of earlier European expeditions, launched freelance depredations on the Spanish Empire in the Caribbean. Portraits of the more famous of these dashing outlaws claimed a prominent place in Alexandre Olivier Exquemelin's extremely popular book, *Bucaniers of America* (1684).

British colonists in North America had set out to man outposts of European culture, but by the last decades of the eighteenth century, they began to see themselves and their new country in a different light. The early settlements along the coast had become established cities: Charleston, Philadelphia, New York, Boston. Among the many views of cities produced by artists is a 1762 composite that explains visually how to civilize the wilderness. This picture brings to mind the idealized landscapes of Currier & Ives a century later. In fact, its romantic feeling is a clear signal that the pioneer era had already come to an end in the Eastern settlements, for one could not afford the luxury of romanticizing the wilderness until it was gone.



By the mid-sixteenth century, French Protestants and Spanish Catholics were fighting one another for a toe-hold in Florida. The simple woodcut of the short-lived French Fort Caroline (1565), the earliest picture of a European settlement in North America, gives a feeling for the fragility of these early outposts. During the seventeenth century, the English and the Dutch vied for New York, while confrontations between England and France for North American land and trade continued throughout most of the eighteenth century. The Indian tribes of North America became inextricably involved in these European entanglements, with dire consequences for their own hard-pressed cultures.

World events of this past year point to the truth of the observation that war makes geography interesting. The North American conflict between England and France during the eighteenth century heralded a cartographic free-for-all that saw nationalistic territorial claims played out on maps even more often than on the battlefield. Conflict was newsworthy, and European publishers scrambled to supply battle plans, city views, and portraits of the antagonists to their eager audiences.



London, Printed for Bowles & Carter, No. 68. St. Pauls Church Yard.

A South-East View of the CITY of BOSTON in North America..





Throughout the colonial period, England's energy and attention was often diverted from close control of her American colonies to more pressing and immediate concerns with her European rivalries. An independent spirit was fostered in the colonies, fanned by the ideas of the Enlightenment and further encouraged by a growing sense in some circles that America, not England, was home. In many popular cartoons and caricatures of these years, America was presented as a wayward child and England as a bumbling, thickheaded adult.

Its independence gained, the young country was visited by Europeans who hoped to discover if the Promise of America, the ideals of the Enlightenment, had come to pass. These visitors documented perceived achievements and failures with words and pictures. In the post-Revolutionary period, admired personalities such as George Washington and Benjamin Franklin actually became "America" in the allegorical prints that issued from the presses of France.

The circle closes as the new Americans began to present Europeans with pictures of a bustling, successful America. William Birch's views of the city of Philadelphia (1800) are the first American-published views of a truly American city.

Susan L. Danforth is Curator at the John Carter Brown Library and curator of the exhibition *Encountering the New World, 1493-1800*. Unless otherwise noted, all photographs are courtesy of the John Carter Brown Library.

The editors thank Errol Stevens, Curator and Section Head of the Seaver Center for Western History Research, for his contributions to this article.

The exhibit was organized by and entirely from the collections of the John Carter Brown Library, U.S. tour organized by the Trust for Museum Exhibitions, Washington, D.C. The John Carter Brown Library is an independently funded and administered rare book library and center for advanced research in the humanities at Brown University. Cost of this traveling exhibition was partially funded by the National Endowment for the Humanities, an agency of the Federal Government.



Book Reviews

THE PRACTICAL PALEONTOLOGIST by Steve Parker, Simon and Schuster, Inc., New York, 1990. Raymond L. Bernor, Editor. Paperback, 160 pages, \$14.95.

STEVE PARKER WORKED FOR A while at the Natural History Museum, London, formerly the British Museum (Natural History), where he wrote exhibition labels and gallery guides. He has a general background in natural sciences, and his new book mainly covers paleontological field and laboratory techniques.

The book has a definite British and European emphasis, as evidenced by the selection of examples and photographs, but is written in relatively direct "American English" and uses many North American examples. It covers most things one would want to know about collecting and caring for fossils, and more. From a curator's perspective, for example, it was pleasant to find advice to amateurs about how to approach museums regarding volunteer work.

Included are discussions of principles of geology, definitions of fossils and fossilization processes, a brief history of collecting, early interpretations (and misinterpretations) of fossils, examples of collecting localities and how to find them, and instructions for getting permission to collect. Also discussed are methods of data recording, cleaning, storage, and exhibition of items. There is a geologic time scale, followed by a summary of the distribution, nature, and fossil content of rocks that represent the major intervals of earth history. The last section recounts, by continent, places to observe fossils and major museums that exhibit and interpret them.

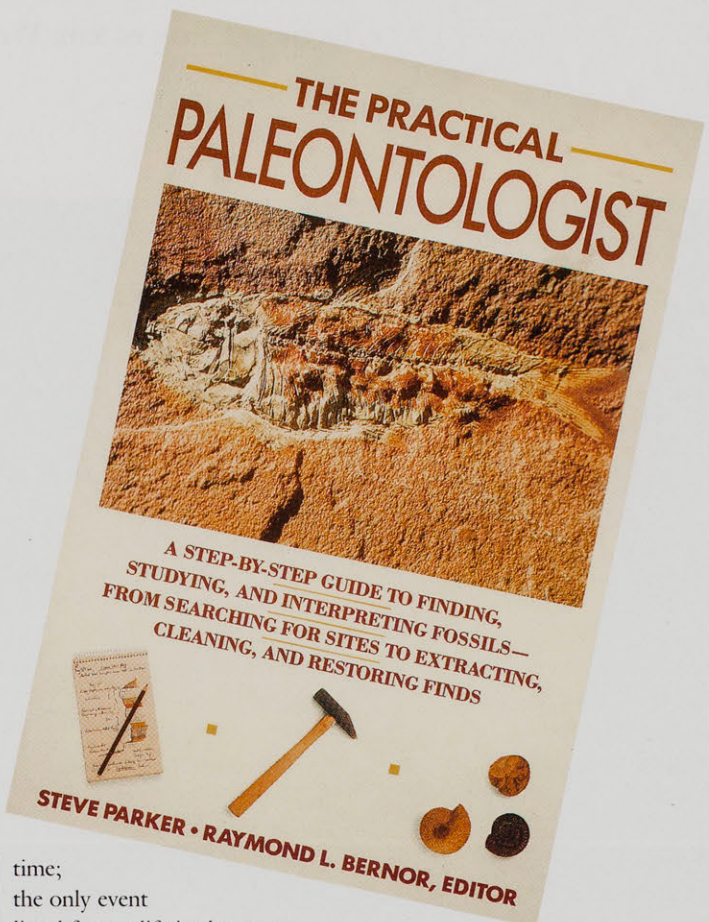
The text is easily readable, with many sidebars and boxes to call attention to special topics, and is generously illustrated on good paper with high quality color photographs, some showing stunning topography and geology. Some of the

line drawings are a bit sketchy and some of the words in the charts and diagrams are crowded together, making for difficult reading. The index is comprehensive and useful.

In general, the book is adequate and informative, but not exhaustive. For example, the book lists only three famous fossil sites in North America, and only five paleontological associations in the world. The list of museums that exhibit fossils is spare, although there is a beautiful photo on page 21 of the Jurassic dinosaur skeletons from Utah in our museum's main foyer. On page 150, our museum is listed as one to visit; also recommended are "fossils from tar pits (Rancho La Brea)," but the George C. Page Museum of La Brea Discoveries is not named.

Because this book will attract the interest of many fossil collectors, some of its problems should be pointed out. One glaring omission is an explanation of how to use field numbers for specimens. This is a widely used convention among professionals, is easily learned, and is much preferable to the sometimes less informative catalog numbers that are often applied to fossils by private collectors long after the specimens have been collected.

Some of the ways of showing ages for the various intervals of earth history in the geologic time chart are non-standard and difficult to understand. For example, the commonly used North American Mississippian and Pennsylvanian Periods are represented by the Carboniferous Period, which is more commonly used in the European chronology, and the Cenozoic Era is incorrectly shown as not including the Pleistocene Epoch (last "Ice Age") and modern time. The chart does attempt to summarize milestones in the geologic and biologic evolution of the earth, including the earliest known records of many plant and animal groups; however, it contains many misstatements, omissions, and errors. Among these, the first appearances of pines, firs and gulls are listed much too early in



time; the only event listed for sea life in the past 54 million years is the replacement of early whales by toothed whales (both incorrect and misstated); and whales and sea cows are listed under "Terrestrial Animal Life." There are bloopers elsewhere in the book as well; for example, a caption on page 28 refers to "underwater sand dunes", and *Ichthyosaurus* is improperly identified on page 18 as a "lizard-fish", when in fact it is a fish-like reptile. There were three different names given for the Dinosaur National Monument in Utah.

Errors and omissions aside, the interested lay person, amateur paleontologist, and private collector will find this book useful and interesting. I highly recommend examining it, and would even recommend it for reading in introductory paleontology classes at the college level, although it certainly should not be the primary text. The book is reasonably priced, and although it should not be the only paleontology volume in a fossil lover's collection, it would make a nice addition to the library of anyone interested in the subject.

LAWRENCE G. BARNES
Curator and Section Head,
Vertebrate Paleontology Section

Southland Diorama

FASTEST CLAW IN THE WEST

PEEERING OUT OF ITS UNDER-water burrow is a formidable carnivore with lightning-quick, predatory reflexes and stalked, compound eyes that acutely scan its environment. Sitting motionless in its lair, the mantis shrimp awaits the right moment to quickly snatch an unwary victim and dispatch its next meal.

Mantis shrimp are fascinating members of a primitive order of Crustacea known as Stomatopoda. They evolved nearly 350 million years ago (at the time reptiles first appeared) from ancestors of the more familiar crabs, lobsters, and shrimp. Often brightly colored, these marine animals comprise about 400 species worldwide. Stomatopods most commonly inhabit warm tropical and subtropical coral reef and rocky bottom environments. There are, however, four species that live in the cooler temperate waters and softer, sandy mud environments found off southern California.

SCUBA divers seldom venture into these sandy mud habitats. Those that do may notice many burrows, about 2½ to 10 centimeters (1-4 inches) in diameter, with shelly debris surrounding the openings. These are the homes of mantis shrimp, and may extend to a depth of three meters (about 10 feet), sometimes running parallel to the sea floor. Burrows play a crucial role in the lives of mantis shrimp and are used for defense, feeding, mating, reproduction, and molting activities. *Hemisquilla ensigera californiensis* (literally translated: sword-bearing half-shrimp inhabiting California) is the largest, most common, and most colorful species of stomatopod found in the waters off southern California. It can grow to a length of 30 cm (11 inches) and can weigh as much as 113 grams (¼ pound). It inhabits nearshore areas from Point Conception, California, to Panama, and lives in the waters surrounding several of California's Channel Islands. Typically living at a depth of 5-70 meters

A SCUBA diver carefully holds a large mantis shrimp (*Hemisquilla ensigera californiensis*) collected off Santa Catalina Island. Note the feathery gills, used in respiration, on the underside of the abdomen.



Norbert Wu

(16-230 feet), it was once collected at a location over a mile deep, at the bathyal depth of 1,800 meters (5,906 feet). Close relatives of this mantis shrimp live in the nearshore waters of Chile, Peru, Australia, and New Zealand.

Its sword-like second thoracopod, or raptorial claw, gives this animal a resemblance to a praying mantis; hence its common name of mantis shrimp. Their claws make mantis shrimp formidable predators, and earns them the record for the fastest movement in the entire animal kingdom. The strike of *Hemisquilla*'s raptorial claw underwater has been clocked at from five- to ten-thousandths of a second (over 22 m.p.h.; as fast as a speeding bullet). The motion must be photographed at 500 frames per second to be visible to the human eye. Some species exert enough power to shatter an aquarium made of double safety glass five centimeters (two inches) thick. *Hemisquilla ensigera californiensis* has a strike force of almost 12 pounds.

The diet of stomatopods consists of a variety of small crustaceans, snails, clams, sand dollars, heart urchins, brittlestars, worms, and fish. The two types of mantis shrimp are separated on the basis of claw structure and function. "Smashers" break open hard-shelled animals with their powerful hammer-like claws; "spearers" grasp soft-bodied prey with claws that are heavily spined.

Coupled with the impressive weaponry of the mantis shrimp is an unusually irascible character for a crustacean. Called "thumb splitters" by commercial shrimp fishermen in the West Indies, who occasionally catch them in their nets, mantis shrimp sometimes victimize SCUBA divers. There are reports of divers in southern California returning to the surface with cut or severed fingers after a confrontation with one of these pugnacious pugilists.

Although some stomatopods may attain a length of more than 40 centimeters (16 inches), most species are no larger than 1.6 centimeters ($\frac{5}{8}$ inch) and are seldom caught in large enough numbers to support a commercial fishery except in the Mediterranean Sea (*Squilla mantis*) and the seas of Japan (*Oratosquilla oratoria*). The tail meat is said to have a delicate flavor, and many fishermen find them delectable additions to their seafaring meals.

The Natural History Museum houses over 350 jars of mantis shrimp representing 41 species from 16 countries. Most of these specimens were collected in the 1930s and 1940s. More recent collecting efforts by museum staff off Central and South America and Africa have enlarged the museum's collection and increased our knowledge of the distribution, behavior and ecology of this group.

HANS G. KUCK
Collections Manager of Crustacea



A mantis shrimp uses its keen compound eyes to forage for prey outside its burrow. Note the raptorial claw, which can deliver a lightning-quick, lethal blow to its prey or to attackers.

A mantis shrimp enters its burrow in the sandy mud habitat found off Santa Catalina Island. Note the heavily armored tail, which can block the burrow entrance. This provides the mantis shrimp protection from predators and other stomatopods.



Southland Diorama is a TERRA column that highlights the incredible diversity of animal and plant life still to be found in southern California. Each issue features an example of one of the many species — extant and extinct, native and introduced, abundant and endangered — that are found in astonishing variety in one of the world's largest urban centers.

The editors thank the BBC, Natural History Division, for use of the title "Fastest Claw in the West."

Museum on the Move

STAFF

■ **DR. JOHN HEYNING** has been promoted from Assistant Curator to Associate Curator of Mammalogy. Dr. Heyning is an expert on cetaceans (whales, dolphins, and porpoises). His publications include studies of the morphology and systematic relationships of cetaceans as well as of basic natural history. His current research deals with the feeding adaptations of beaked whales, aging of killer whales, and several conservation projects.

Dr. Heyning serves as Head of the Section of Birds and Mammals. He is also an Adjunct Assistant Professor of Biology at the University of California, Los Angeles. He received his Ph.D. from U.C.L.A. in 1986.

C.F. Lütken, Danish Zoologist, 1827-1901. This picture was made in 1890.

GRANTS

■ **NATURAL HISTORY MUSEUM RECEIVES PACIFIC TELESIS GRANT** The Classroom Collections Program, one of the most popular programs at the Natural History Museum, will benefit from a \$25,000 grant from the Pacific Telesis Foundation to help support the museum's 65-year practice of lending pieces from its collections to local schools. Under the program, schools "rent" one of 30 specifically designed teaching collections for an entire academic year. Each collection contains some 200 museum specimens and permits children to closely inspect science specimens, minerals, and fossils; to study the material culture of the North American Indians; and to relive key elements in California and United States history.

The foundation, created in 1984 by the parent of Pacific Bell and PacTel Companies, is one of the largest providers of charitable funding in California.

There is a waiting list for this popular program. For information, please call 213/744-3345.



■ **COELACANTH RESEARCH GRANT** The National Geographic Society awarded a grant of \$5,400 to Dr. David Schwimmer, of Columbus College, and Dr. J. D. Stewart, Assistant Curator of the museum's Vertebrate Paleontology Section, for the study of giant coelacanth fishes from Upper Cretaceous rocks in Alabama. Until recently, it was thought that the last North American coelacanths expired during the Jurassic Period, more than 150 million years ago. Drs. Stewart and Schwimmer, however, have discovered in the Blufftown and Mooreville Chalk formations of Alabama some bones belonging to coelacanths estimated to have been more than 12 feet long. These specimens represent a new, unnamed species that seems to be the largest of all known coelacanths, and, at less than 83 million years old, the youngest in the fossil record. The best specimen will be donated to our museum and will become the holotype. It will join two rare specimens

of the only surviving species of coelacanth, *Latimeria chalumnae*, owned by the museum.

■ **PALEONTOLOGY EXCAVATIONS IN WASHINGTON STATE AND MEXICO** The National Geographic Society has awarded a two-year grant of \$5,000 to Dr. Lawrence G. Barnes, Curator and Section Head of Vertebrate Paleontology, to support research on fossil whales from the Olympic Peninsula. The grant will support the continuation of field work by Museum Associate Mr. James L. Goedert, and Field Associate Mrs. Gail H. Goedert, of Gig Harbor, Washington, and Dr. Barnes, who have made important new discoveries of Eocene, Oligocene, and Miocene marine vertebrate fossils from coastal outcrops in Washington. The aim of the project is to retrieve early fossil whales that will reveal the origins of modern groups of toothed and baleen whales.

Dr. Barnes and associates

BELOW OPPOSITE ►

This beautifully preserved dolphin skull, 1½ feet long and some 7 million years old, is from the rich fossil beds of Isla Cedros, off the Baja California coast. It is named *Albireo whistleri* after its discoverer, David Whistler, Curator of Vertebrate Paleontology.

have also received \$7,200 from the National Geographic Society and the Foundation for Field Research (FFR) to carry out excavations on Isla Cedros, off the Baja California coast. Fossil-producing beds on the island that are six to nine million years old have in the past yielded many important and excellently preserved fossils of whales, dolphins, porpoises, sea lions, fishes, and marine birds. Several new fossil species from Isla Cedros have been described by Dr. Barnes and by Dr. Hildegard Howard, Chief Curator Emeritus.

The Foundation for Field Research, headquartered in Alpine, California, recruits volunteers who pay their way to work with scientists, and will support two month-long excavations at Isla Cedros in 1992 and 1993. It is expected that many new fossil skeletons will be recovered and made available for research, publication, and exhibit.

■ **AMERICAN PHILOSOPHICAL SOCIETY GRANT TO FUND COLLABORATION** Dr. Gordon Hendler, Head of the museum's Invertebrate Zoology Section

and Curator of Echinoderms, has been awarded \$3,000 by the American Philosophical Society to carry out research at the Zoological Museum in Copenhagen, Denmark.

The subjects of his research, brittlestars, comprise the most species-rich class of the phylum Echinodermata (seastars and their relatives); thus they constitute a prominent component of the earth's biodiversity.

Since 1988, Dr. Hendler has collaborated with Mrs. Karen J. Friedmann, a Museum Associate, to prepare an annotated translation of C. F. Lütken's monograph on the brittlestars, published in Denmark between 1854 and 1899. Lütken, the first Danish doctor of zoology, set a new standard for scholarship in invertebrate zoology, melding original observations on morphology and natural history with meticulously detailed taxonomic descriptions.

Due to Mrs. Friedmann's perseverance and linguistic skills, an English version of the 319 pages of Danish text is now largely complete.

The American Philosophical Society grant will support the study and photography of the 77

brittlestar species that Lütken described and some of the 44 species that he redescribed. These illustrations will constitute a "Rosetta stone" for the identification of an ecologically and phylogenetically important class of marine invertebrates.

COLLECTIONS

■ **MUSEUM ACQUIRES BAXTER COLLECTION OF ALASKAN MOLLUSKS** A large and comprehensive collection of marine mollusks from Alaska has been donated to the Malacology collection by the family of the late Rae Baxter of Homer, Alaska, who had been an Associate in Malacology at the museum. He was the leading authority on the Alaskan mollusk fauna, having collected for many years during his tenure as a fishery biologist with the Alaska Fish and Game Department. Using his collection as a basis, he published several editions of a detailed checklist of the mollusks of Alaska. His extensive collection greatly enhances the museum's representation of eastern Pacific mollusks.

See also *Acquisitions*, page 2.

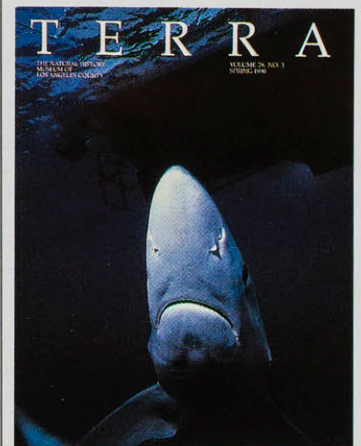


Lawrence G. Barnes

AWARDS

■ **TERRA WINS AAM AWARD** The Spring 1990 issue of *TERRA* was winner of an Award of Merit given for graphic design by the American Association of Museums in its 1991 Publications Competition. The issue, which featured a dazzling photo of a blue shark on the cover, was designed by Armin Krumbach of Tri-Arts.

The contest is the only national juried event for museum publications and drew 1,639 entries and granted 131 honors, three of which were Awards of Merit granted to magazines. Winners were featured in the September/October 1991 issue of AAM's magazine, *Museum News*.



■ **PRODUCTIVITY AWARDS PRESENTED TO EDUCATION PROGRAMS** At the end of 1991, The Los Angeles County Productivity Commission presented awards to two of the museum's outstanding education outreach programs: the Earthmobile and the Traveling Insect Zoo. The Earthmobile, a mobile museum and laboratory, provides scientific enrichment to students in grades 3-6 in the Los Angeles Unified School District.

UNIQUE Adventure Tours

Journey across the Himalayas – from Lhasa to Kathmandu – September 5, 1992

China – The Ancient Silk Road – from Xi'an to Kashgar and along the Karakorum Highway into Hunza – September 30, 1992

The Grand Tour of India – palaces, forts, temples and tigers – October 9, 1992

Exotic Islands of Indonesia, Borneo and Malaysia – October 23, 1992

East African Safaris – Kenya, Tanzania and the Seychelles – August and October 1992

The Himalayan Kingdoms – Ladakh, Nepal, Sikkim and Bhutan – October 30, 1992

Highlights of Australia and the Great Barrier Reef – October 30, 1992

Northwestern Australia – a Special Expedition from Darwin to Perth – Spring 1993

For a detailed itinerary, please write to:

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Santa Ynez, CA 93460
or telephone: (805) 688-3299

Please keep me on your priority mailing list for 1992 special tours and expeditions.

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Address: _____

City: _____ State: _____ Zip: _____

The Traveling Insect Zoo visits schools, fairs, and camps with a presentation on insects and some of their close relatives. It is estimated that the two programs will serve over 75,000 Los Angeles County residents this year.

■ **PUBLIC RELATIONS OFFICE RECOGNIZED** In September the Public Relations Office received a PRISM merit award from the Public Relations Society of America for its campaign publicizing the exhibit Tropical Rainforests: A Disappearing Treasure. This is the office's third award in the past two years.

DEVELOPMENT

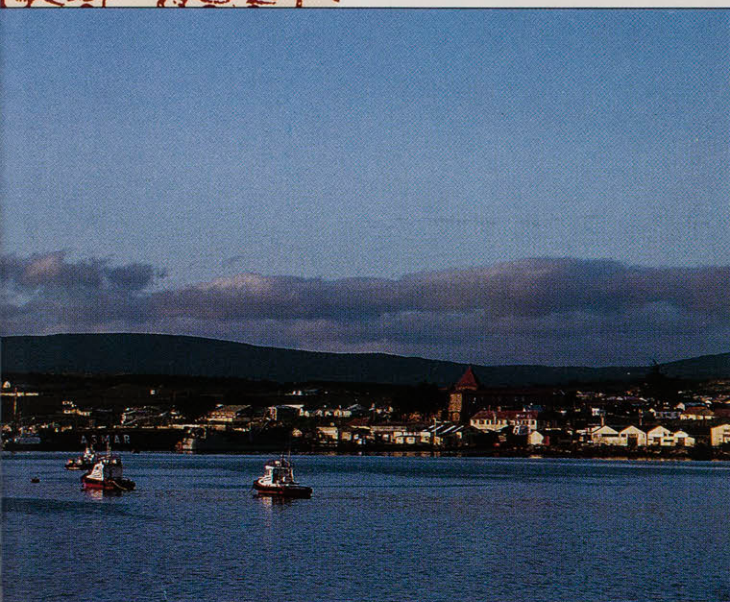
■ **FELLOWS** Museum Fellows took care of their holiday gift lists early in December when the museum shops opened just for them. Authors, including Fellows Buzz Aldrin, Mary Nichols, Shauna Sorenson, and Erica and Harold Van Pelt, autographed copies of their work for the Fellows. In January, on a hill high above the Malibu coastline, the Fellows joined a group of astronomers to watch the annular eclipse. Irish coffee kept the chill off and spirits high when clouds obscured this celestial experience. Dinner provided by Fellows Liisa Larson and Steven Buehler followed at the home of Fellows Sandy and Paul Russell. On March 7th, the Fellows met Native American sculptor Allan Houser, who provided a gallery tour of his retrospective exhibition at the museum. The Los Angeles Marathon brought runner and Oxford University Professor Norman Myers to Los Angeles, and the Fellows traveled to the Hollywood Hills home of Audrey and Mike Hollander to hear him talk about development and the environment. The museum welcomes new Fellows Joyce Black, Helene and Robert Beck, Judy Cobb, Irwin Field, Werner Wolfen, and Fran and Dick Van Duzer.

■ **CORPORATE AND FOUNDATION SUPPORT** Over 50 Business Associates and other museum donors attended the second of three museum luncheons for the corporate community. UNOCAL C.E.O. Richard Stegemeier spoke about energy and the environment, and guests heard presentations on the museum's scientific research and environmental programs. The museum is pleased to welcome new Business Associates Isuzu Companies and the Spring Street Foundation, and returning Business Associates Southern California Edison, Web Service Company, Sanwa Bank, and Union Bank.

The Texaco Foundation generously supported events and educational programs related to Court Arts of Indonesia in the Fall of 1991. Texaco provided educational kits containing maps and lesson materials that were mailed to teachers throughout Los Angeles and Orange Counties.

Chase Manhattan, United States Borax and Chemical Corporation, and Millicent Boudjakdji provided support for Allan Houser: A Life in Art. The Confidence Foundation and J.C. Penney provided generous gifts that allow the museum to open to the public free of charge on the first Tuesday of every month. The Homeland Foundation and the Smith Welsh Foundation provided support for the museum's environmental education program. Great Western Bank made a gift to the educational programs at Hart Park, while the Brotman Foundation funded the Senior Outreach program and Sunrise Medical the Special Education Outreach program. A grant for educational programs was provided by the Henry W. Bull Foundation, and a gift from the Flora Thornton Foundation helps the museum offer 30 talented high school students the opportunity to study science for a full year with museum curators and educators.

OUR VIEW TO THE WORLD



BEHIND THE VEIL OF MOROCCO

October 10-24, 1992

Meet us at the Kasbah in Tangier. Visit royal palaces and museums along the road from Rabat to the minaret-studded city of Fez. Drive through the Atlas Mountains to Erfoud, gateway to the Sahara. Shop in the lively and colorful marketplace of Marrakesh. Conclude your adventure in Casablanca.

\$3,211 plus air fare.

THE TREASURES OF INDIA

October 11 - November 9, 1992

Exalt in the natural history and rich culture of this diverse country, where 5,000 years of continuous civilization have left a legacy of temples, monuments, and palaces. Visit Nagarhole and Kanha National Parks, where we may view tiger, elephant, leopard, and more than 200 bird species. With study leader Dr. Julian Donahue.

\$4,190 plus air fare.

ALL PHOTOS: PUNTA ARENAS, CHILE
PHOTOGRAPHER: ERIC HOVANITZ

CHILE AND ARGENTINA

November 28 - December 12, 1992

From Santiago, bordered by the soaring Andes, fly to Punta Arenas. Study the natural history and native peoples of Patagonia and Tierra del Fuego. Visit Paine Towers National Park, South America's largest and finest wildlife preserve. Tour Puerto Montt before concluding your stay in cosmopolitan Buenos Aires.

\$3,100 plus air fare.

YUCATÁN, LAND OF THE ANCIENT MAYA

November 30 - December 13, 1992

Each site on our tour has been carefully chosen to reveal a different facet of the history, religion, and art of the Maya and Olmec civilizations, including the magnificent ceremonial centers of Uxmal, Chichen Itza, Tulum and Palenque.

With study leader
Dr. Richard D. Hansen.

\$2,495 plus air fare.



AND COMING IN 1993...

Belize, January. An archaeological and natural history adventure led by Dr. Richard D. Hansen.

Among the Great Whales, March. Baja California and the Sea of Cortez aboard the "Sea Lion."

Columbia River, May. An historic trip through Oregon and Washington in spring aboard the "Sea Lion."

Hudson's Bay, October. See Polar Bears by tundra buggy.

Egypt, October. Cruise the Nile by luxury yacht.

Guatemala, December. Mayan archaeology with Dr. Richard D. Hansen.

*For further information,
please contact
Karen Hovanitz
Natural History Museum
Travel Program
(213) 744-3350*

NATURAL HISTORY MUSEUM

Travel Program

1992





ENCOUNTERING THE NEW WORLD

In conjunction with this year's
quincentennial exhibition

The Museum Bookstore offers both an
exhibition catalog and poster



Like the exhibition,
the catalog,
**ENCOUNTERING
THE NEW WORLD**
1493 - 1800, concentrates on
the subject of what Europeans
knew of the New World
visually before about 1800,
well before the era of
photography or even mass-
produced lithography. The
replication of visual images in
this age depended upon the
woodcut and the engraved
copper plate. This beautiful
catalog showcases a selection
of these fascinating images
from the exhibition and is
illuminated with descriptions
and background information.
Included at the end of the
book is a short-titled list and
photograph of every item in
the exhibition.

The dramatic full-color poster measures a large
23" by 38" and features the "Parrot of
Paradise," an 18th-century engraving by Mark
Catesby. Explorers were especially impressed by
the parrots of the West Indies and South America,
which were larger and more brightly colored than the
African species that were already known in the courts
of Europe. Columbus mentioned these vividly colored
birds in his "Letter" of 1493.



Exhibition Poster:
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softcover, \$25.
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